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ELECTRONICS

JUNE 1981

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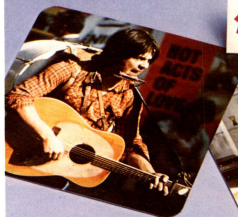
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Your prints will normally be despatched within five working days of receipt, but please allow for postal times and possible delays.

PRACTICAL ELECTRONICS

VOLUME 17

No. 6

JUNE 1981

CONSTRUCTIONAL PROJECTS

PE MINITUNE by Martin Kent	34
For r.p.m., dwell, voltage and resistance testing	
pH METER by Martin Kent	40
Provides an accurate measurement of pH values in the range 0–14pH	
SEMICONDUCTOR CURVE TRACER by D. Mandelzweig	50
Transistor and diode characteristics displayed on your scope	
CONTINUITY TESTER by Martin Kent	64
Provides resistance measurements in the range 0.1Ω–20M	
INTERFACING COMPUKIT Part 6 by D. E. Graham	68
Manipulating the VIA	

GENERAL FEATURES

WIRE WRAPPING by John Lewis	24
An introduction to a simple and effective form of wiring	
WEMON REVIEWED by Dr A. A. Berk	26
Another UK101/Superboard monitor looked at	
SEMICONDUCTOR UPDATE by R. W. Coles	31
CY500 LM330	
STRICTLY INSTRUMENTAL by K. Lenton-Smith	38
The history of a pioneer in the organ world	
OSCILLOSCOPES . . . HOW THEY WORK Part 3 by Ian Hickman	45
Circuitry	
POSITIVE IMPEDANCE CONVERTORS by A. B. Bradshaw	58
The use of gyrators in the design of filters	
MICROBUS By D. J. D.	76
Acorn Atom games, dynamic ZX80 graphics	

NEWS AND COMMENT

EDITORIAL	17
NEWS & MARKET PLACE	18
Including Countdown and Points Arising	
INDUSTRY NOTEBOOK by Nexus	23
Triumphing over the recession	
EXTRA CASE COUPON	28
To save you money on another case	
SPACEWATCH by Frank W. Hyde	32
Keeping you up to date with extra-terrestrial activity	
SPECIAL OFFER—CAR AUDIO BOOSTER	39
Yet another unrepeatable bargain	
READOUT	44, 79
Criticism of the controversial	
SPECIAL OFFER—DIGITAL PANEL METER	57
Use it with our free case	
PATENTS REVIEW	78
A 7in. cube that delivers 500 watts of audio power!	

OUR JULY ISSUE WILL BE ON SALE FRIDAY, 12 JUNE 1981

(for details of contents see page 33)

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DIGITAL THERMOMETER

This is one of our range of PROJECT KITS. It includes all the parts required to complete the project, including the case. Calibration is very simple and an accuracy of up to 1% can be obtained. The instrument covers the range -50°C to +150°C. Read-out is on an LCD display. Power requirement is a 9V Battery. An ideal instrument for home or laboratory. Full instructions included.



PROJECT KIT 800104 £26.50

MUSICAL BOX

This 'electronic musical box' can be used in a variety of applications. These include toys, video games and doorbells. It can be programmed to play no less than 27 tunes. The circuit is based on the AY-3-1350 which offers a considerable improvement over similar devices. The output can be switched from 'piano' to 'organ' like quality. The project includes all the components, case, loudspeaker and full instructions. An easy project for the beginner. An additional amplifier is available if required.

PROJECT KIT 80502K £25-95 (Musical Box)
PROJECT KIT 80543K £3-95 (Stamp Amplifier)

HIGH COM NOISE REDUCTION SYSTEM

The High COM system of noise reduction, developed by TELEFUNKEN, offers considerable advantages over existing systems. The Compressor/Expander circuits are designed around a specially designed IC, the U401B. The unit is designed for use with cassette and reel-to-reel tape systems to give professional quality, low noise recordings.

TECHNICAL SPECIFICATIONS:

Frequency Range 20-18kHz (+0, -3dB)
Signal/Noise ratio 80dB (DIN input)
85dB (Socket input)
Input Sensitivity DIN 0.6mV/6k ohm
Output Sensitivity DIN 130mV/79k ohm

Distortion less than 0.2%
Noise reduction at 100Hz : 15dB
at 3kHz : 20dB
at 15kHz : 25dB

FULL SPECIFICATION AVAILABLE

The project packs include all the electronic components, self adhesive front panel, prebuilt and tested HIGH COM modules and PCBs. The meter circuit uses an LED bar display and is essential for the operation of the unit.

HIGH COM (81117-1) £49-55
Meter/Display (9860 + 9817) £15.40

HIGH COM Power Supply (8117-2) £14.50
Case for project POA

DISCO PROJECTS

MINIMIXER

This mixer is easy to assemble, most parts are mounted on the single PCB. It incorporates two stereo disc inputs, two microphone inputs and a stereo tape input. Slider controls for level controls, rotary pots for tone controls. Distortion is approx 0.1%, frequency response 20Hz to 25kHz (3dB)

Project Pack 81068 £37-50 Case £7-50

DISCO LIGHTS

This ceiling lights project controls a matrix of 25 x 100W lamps. A pre-programmed IC switches them in 22 different sequences of patterns. Patterns can be repeated if required. Triac controlled outputs. Lamps not supplied. Mains operation.

Project Pack 81012 £53-95

SWINGING POSTER

A specially printed poster comes to life when the red and green lamps powered by this circuit are switched on. A random sequence makes the disco girl appear to dance. Poster included. Lamps not provided (100W)

Project Pack £17-70

HOW TO ORDER

Send a cheque or postal order to DORAM ELECTRONICS LTD or write or ring with your ACCESS account number. All our prices include VAT at 15%. Overseas customers please deduct 15%. Please add 40p to the cost of all UK orders for postage and packing. An answering service is available to take your orders outside our normal office hours. We are a MAIL ORDER business.
SUMMER ISSUE OF OUR CATALOGUE AVAILABLE - Send 14p stamp for your copy.
PROJECT PACKS include PCB, Components and data, Cases etc extra.



PROJECT PACKS

Pools Predictor (79053) LED Display £ 8-15
Ioniser (9823) Negative ion generator £10-50
Talk Funny (80052) Ring Modulator £10-00
Photo Process Timer (81101) £18-20
Cackling Egg Timer (9985) It clucks! £ 2-20
Sound Effects Unit (81112) Guns, trains etc £ 8-30
Elektornado (9874) 100W power Amp £19-50
Top-preamp (80023) HiFi preamp £34-40
Guitar Preamp (77020) £ 6-50
Analogue Reverb (9973) 100mS delay £27-70
Elektor Vocoder (80068) 10 channels £162-50
2½ Digit DVM (81105) £23-35
AM Receiver (81111) Easy to build £10-25
Touch switch (81008) 12 positions £10-00
200W Disco Power Amp (81082) £20-85
Swinging Poster (81073) Moving picture £17-20
STAMP (80543) Mini amplifier £ 3-75
Steam Train Sound (80019) sound effects £ 6-50
Pest Pester (80130) Insect repellent £ 2-35
Stereo Disc Preamp (80532) £ 5-20
Programmable Car Wiper delay (80086) £15-85
Active Car Aerial (80018) AM/FM amplifier £13-85
Aerial Booster (80022) £ 5-65

Full list in our new catalogue.

DORAM
ELECTRONICS LTD

Fitzroy House, Market Place,
Swaffham, Norfolk PE37 7QH

Tel: (0760) 21627

Unique in concept - the home computer that grows as you do!

-The Acorn Atom

£120 An outstanding personal computer kit
plus VAT and p&p.

Also available ready-built

£150
plus VAT and p&p

The ATOM - a definitive personal computer. Simple-to-build, simple-to-operate. But a really powerful full-facility computer. And designed on an expandable basis. You can buy a superb expanded package now - tailored to your needs. Or, you can buy just the standard Atom kit, and, as you grow in confidence and knowledge, add more chips. No need to replace your equipment. No need to worry that your investment will be overtaken by new technology. As you need more power, more facilities, you can add them!

*The picture shown demonstrates mixed graphics and characters in three shades of grey provided by the Standard Atom.

NEW!
Colour Encoder
for full colour
graphics
£21.50



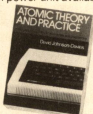
The standard ATOM kit includes:

- Full sized QWERTY keyboard
- Rugged polystyrene case
- Fibreglass PCB
- 2K RAM
- 8K ROM
- 23 integrated circuits
- Full assembly instructions including tests for fault-finding. (Once built, connect it to any domestic TV and power source)
- Power requirement: 8V at 800 M.A. ATOM power unit available.

See coupon. PLUS FREE MANUAL written in two sections - teach yourself BASIC and machine code for those with no knowledge of computers, and a reference section giving a complete description of the ATOM's facilities. All sections are fully illustrated with example programs.

The ATOM concept

Adding chips into sockets on the PCB allows you to progress in affordable steps to large-scale expansion. You can see from the specifications that the RAM can be increased to 12K allowing high resolution (256 x 192) graphics. Two further ROM chips, e.g. maths functions, can be added directly to the board giving a 16K capacity. In addition to 5 I/O lines partly used by the cassette interface, an optional VIA device can provide varied I/O and timer functions and via a buffer device allow direct printer drive. An optional module provides red, green and blue signals for colour. An in-board connector strip takes the ATOM communications loop interface. Any number of ATOMs may be linked to each other - or to a master system with mass storage/



hard copy facility. Interface with other ACORN cards is simplicity itself. Any one ACORN card may be fitted internally. So you can see there are a vast number of modular options and additions available, expanding with your ability and your budget.

The ATOM hardware includes:

- Memory from 2K to 12K RAM on board (up to 35K in case)
- 8K to 16K ROM (two 4K additions)
- 6502 processor
- Video Display allows high resolution (256 x 192) graphics and red, green and blue output
- Cassette Interface - CUTS 300 baud
- Loudspeaker allows tone generation of any frequency
- Channel 36 UHF Modulator Output
- Bus output includes internal connections for Acorn Eurocard.

The ATOM software includes:

- 32-bit arithmetic ($\pm 2,000,000,000$)
- High speed execution
- 43 standard/extended BASIC commands
- Variable length strings (up to 256 characters)
- String manipulation functions
- 27 32-bit integer variables
- 27 additional arrays
- Random number function
- PUT and GET byte
- WAIT command for timing
- DO-UNTIL construction
- Logical operators (AND, OR, EX-OR)
- LINK to machine-code routines
- PLOT DRAW and MOVE.

**ACORN
COMPUTER**

4a Market Hill,
CAMBRIDGE CB2 3NJ

Your ACORN ATOM may qualify as a business expense. To order complete the coupon below and post to Acorn Computer for delivery within 28 days. Return as received within 14 days for full money refund if not completely satisfied. **All components are guaranteed with full service/repair facility available.**

Quantity	Item	Item price inc. VAT+p&p	TOTALS
	ATOM KIT-8K ROM+2K RAM (MIN)	@ £140.00	
	ATOM ASSEMBLED-8K ROM+2K RAM (MIN)	@ £174.50	
	ATOM KIT-12K ROM+12K RAM (MAX)	@ £255.00	
	ATOM ASSEMBLED-12K ROM+12K RAM (MAX)	@ £289.50	
	1K RAM SETS	@ £11.22	
	4K FLOATING POINT ROM (inc. in 12K version)	@ £23.30	
	PRINTER DRIVE 6522 VIA	@ £10.35	
	(inc. in 12K version) LS244 Buffer	@ £3.17	
	COLOUR ENCODER	@ £21.50	
	MAINS POWER SUPPLY (1.3 amps)	@ £10.20	
	TOTAL		

To: Acorn Computer Ltd., 4a Market Hill, CAMBRIDGE CB2 3NJ

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PE/6/81



D.Y. KITS FOR SYNTHESISERS, SOUND EFFECT

PHONOSONICS

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COMPONENTS TO A WORLD-WIDE
MARKET

BASIC COMPONENTS SETS include all necessary resistors, capacitors, semiconductors, potentiometers and transformers. Hardware such as cases, sockets, knobs, keyboards, etc. are not included but most of these may be bought separately. Fuller details of kits PCBs and parts are shown in our lists.

LAYOUT DIAGRAMS are supplied free with all PCBs unless "as published".



P.E. MINISONIC MK2 SYNTHESISER

A portable mains operated miniature sound synthesiser with keyboard controls. Although having slightly fewer facilities than the large Formant synthesiser the functions offered by this design give it great scope and versatility. 3 Oct KBD & GJ contacts needed.

Set of basic component kits (excl. KBD R's & tuning pots) - see list for options available and PCBs (incl. layout charts) **£30.14**
"Sound Design" booklet **£1.00**
Knobs, sets, sw's **See our list**

P.E. 128-NOTE SEQUENCER

Enables a voltage controlled synthesiser to automatically play pre-programmed tunes of up to 32 pitches and 128 notes long. Programs are keyboard initiated and note length and rhythmic pattern are externally variable. 4 Oct KBD and GJ contacts needed.

Set of basic comps, PCBs and charts **KIT 6-7 £35.56**
Set of test photocopies **TEXT 76 £1.36**
Knobs, sets, sw's **HW 76 £6.62**

P.E. 16-NOTE SEQUENCER

Sequences of up to 16 notes may be programmed by the panel controls and fed into most voltage controlled synthesizers. Set of basic comps, PCBs and charts **KIT 86-5 £32.10**
Set of test photocopies **TEXT 86 £1.84**
Knobs, sets, sw's **HW 86 £11.15**

P.E. STRING ENSEMBLE

A multivoiced polyphonic string instrument synthesiser. Set of basic comps, PCBs and charts **KIT 77-8 £109.72**

ELEKTOR CHOROSYNTH

A 23-octave Chorus synthesiser with an amazing variety of sounds ranging from violin to cello and flute to clarinet amongst many others. Experienced constructors can readily extend the octave coverage. 3 Oct KBD and GJ contacts needed.
Basic comps, PCBs and charts **KIT 100-8 £44.39**
Text photocopy **TEXT 100 70p**
Knobs, sets, sw's **HW 100 £11.55**

ELEKTOR FORMANT SYNTHESISER

A very sophisticated synthesiser for the advanced constructor who puts performance before price.
Set of basic comps, PCBs (as publ.) **KIT 66-14 £255.45**
Set of test photocopies **TEXT 66 £7.83**
Knobs, sets, sw's **See our list**

ELEKTOR DIGITAL REVERB UNIT

A very advanced unit using sophisticated i.c. techniques instead of mechanical spring lines. The basic delay range of 24 to 90ms can be extended up to 450ms using the extension unit. Further delays can be obtained using more extensions.
Main unit basic comps and PCB (as publ.) **KIT 78-3 £49.96**
Extension unit comps and PCBs **KIT 78-4 £38.95**
Text photocopy **TEXT 78 86p**
Knobs, sets, sw's **HW 78 £2.94**

ELEKTOR ANALOGUE REVERB

Using i.c.s instead of spring-lines the main unit has a maximum delay of up to 100ms, and the additional set extends this up to 200ms. May be used in either mono or stereo mode.
Main unit basic component set **KIT 83-4 £29.23**
Additional Delay basic components **KIT 83-4 £20.07**
PCB (as publ.) to hold both kits included in **KIT 83-4**
Text photocopy **TEXT 83 67p**
Knobs, sets, switch **HW 83 £2.84**

ELEKTOR SEWAR

For use with Elektor Analogue Reverb to give greater flexibility to the reverb effects.
Basic comps, PCB (as publ.) **KIT 101-1 £18.19**
Text photocopy **TEXT 101 60p**
Knobs, sets, switch **HW 101 £2.44**

**WE ALSO SELL
COMPONENTS
ASK FOR OUR LIST**

NEW KITS

EE 3-CHAN STEREO MIXER

Full level control on left and right of each channel, and with master output control and headphones monitor.
Basic comps, PCB & chart **KIT 107-1 £8.61**
Text photocopy **TEXT 108 65p**
Knobs, sets & sw's **HW 107 £3.19**

3-MICROPHONE STEREO MIXER

Enables stereo live recordings to be made without the "hole in the middle" effect. Independent control of each microphone.
Basic comps, PCB & chart **KIT 108-1 £5.41**
Text photocopy **TEXT 108 55p**
Knobs, sets, & sw's **HW 108 £2.55**

E.E. HEADPHONE AMPLIFIER

For use with magnetic, ceramic or crystal pick-ups, tapedeck or tuner, and for most headphones. Designed with RIAA equalisation.
Basic comps, PCB & chart **KIT 104-1 £9.79**
Text photocopy **TEXT 104 85p**
Knobs, & sockets **HW 104 £2.50**

E.E. AUDIO EFFECTS UNIT

A variable series generator that can produce British & American police sirens, Star Trek, Red Alert, heart-beat monitor sounds, etc.
Basic comps, PCB & chart **KIT 105-1 £4.87**
Text photocopy **TEXT 105 65p**
Knobs, skts & switch **HW 105 £1.91**

GUITAR PRACTISE AMPLIFIER

A 3 watt mains powered amplifier suitable for instrument practice or as a test gear monitor. Drives 8 or 15 ohm loudspeaker.
Basic comps, PCB & chart **KIT 106-1 £9.81**
Text photocopy **TEXT 106 65p**
Knobs, skts, switch **HW 106 £2.02**

SIGNAL TRACER & GENERATOR

Allows audio signals to be injected into circuits under test, and for tracing their continuity. Includes frequency & level controls.
Basic comps, PCB & chart **KIT 109-1 £5.80**
Text photocopy **TEXT 109 55p**
Knobs, sets, sw's & probes **HW 109 £3.17**

P.E. GUITAR SUSTAIN

Maintains the natural attack whilst extending note duration.
Basic comps, PCB & chart **KIT 75-1 £6.99**
Text photocopy **TEXT 75 38p**
Knobs & sets **HW75 91p**

P.E. AUTO-WAH UNIT

Automatically gives Wah or Swell sounds with each note played.
Basic comps, PCB & chart **KIT 58-1 £0.11**
Text photocopy **TEXT 58 55p**
Knobs & skts **HW58 £1.26**

ELEKTOR WAVEFORM CONVERTER

Converts a saw-tooth waveform into sinewave, mark-space sawtooth, regular triangle, or square-wave with variable mark-space.
Basic comps, PCB & chart, but excl. sw. **KIT 67-1 £9.24**
Knobs, skts, sw's **HW 67 £4.23**

P.E. SWITCHED TONE TREBLE BOOST

Provides switched selection of 4 preset tone responses.
Basic comps, PCB & chart **KIT 89-1 £4.34**
Text photocopy **TEXT 89 78p**
Knobs, sets, sw's **HW 89 £1.89**

ELEKTOR RING MODULATOR

Compatible with the Formant & most other synthesizers.
Set of basic comps & PCB (as publ.) **KIT 87-2 £6.84**
Text photocopy **TEXT 87 35p**
Knobs, set **HW 87 £1.22**

ADD-POST & HANDLING

U.K. orders: Keyboards add £2.70 each. Other goods: Under £5 add 50p, under £20 add 75p, over £20 add £1. Recommended insurance against postal mishaps: add 50p for cover up to £50, £1 for £100 cover, etc., pro-rata. Insurance must be added for credit card orders.
N. B. Eire, C.I., B.F.P.O. and other countries are subject to higher export postage rates.

ADD 15% VAT

(for current rate if changed). Must be added to full total of kits, discount post & handling on all U.K. orders. Does not apply to Exports, or to photocopies.

ELEKTOR FUNNY TALKER

Incorporates a ring modulator, chopper & frequency modulator to produce fascinating sounds when used with speech & music.
Basic comps, PCB (as publ.) **KIT 99-1 £9.60**
Text photocopy **TEXT 98 20p**
Knobs & sets **HW 99 £1.22**

ELEKTOR FREQUENCY DOUBLER

For use with guitars & other electronic instruments to produce an output one octave higher than the input. Inputs and outputs may be mixed to give greater depth.
Basic comps, PCB (as publ.) **KIT 98-1 £5.48**
Text photocopy **TEXT 98 20p**
Knobs & sets **HW 98 £1.24**

P.E. SPLIT-PHASE TREMOLO

A simple but effective substitute for a rotary cabinet. The output of an internal generator is phase-split and modulated by an input signal from an electronic guitar or other instrument. Output amplitudes, depth & rate are variable. May be fed to one or two amplifiers.
Basic comps, PCB & chart **KIT 101-3 £1.68**
Text photocopy **TEXT 102 £2.53**
Knobs & skts **HW 102 £2.53**

P.E. MINISONIC WAVEFORM CONVERTER

A simple converter that modifies the Minisonic sawtooth waveform to produce triangle and sine outputs. Ideally one should be used with each Minisonic VCO.
Basic comps, PCB & chart **KIT 96-1 £3.98**
Knobs, skts, switch **HW 96 99p**

P.E. GUITAR MULTIPROCESSOR

An extremely versatile sound processing unit capable of producing, for example, flanging, vibrato, reverb, fuzz and tremolo as well as other fascinating sounds. May be used with most electronic instruments.
Basic comps, PCBs & charts (excl. Sw's) **KIT 85-5 £49.23**
Set of test photocopies **TEXT 85 £2.52**
See our list

P.E. PHASER

An automatically controlled 6-stage phasing unit with integral oscillator.
Basic comps, PCB & chart **KIT 88-1 £10.91**
2-Notch extension, PCB & chart **KIT 88-2 £6.36**
Text photocopy **TEXT 88 68p**
Knobs, skts, switch **SW 88 £1.63**

ELEKTOR PHASING & VIBRATO

Includes manual and automatic control over the rate of phasing & vibrato. Slightly modified to also include a 2-input mixer stage.
Set of basic comps, PCB & chart **KIT 70-2 £21.67**
Text photocopy **TEXT 70 67p**
Knobs, sets, sw's **HW 70 £3.27**

P.E. GUITAR EFFECTS UNIT

Modulates the attack, decay and filter characteristics of a signal from most audio sources, producing 8 different sound effects that can be further modified by manual controls.
Basic comps, PCB & chart **KIT 42-4 £7.68**
Text photocopy **TEXT 42 28p**
Knobs & sets **HW 42 £1.95**

P.E. GUITAR OVERDRIVE

Sophisticated versatile fuzz unit incl. variable controls affecting the fuzz quality whilst retaining attack and decay, and also providing filtering. Suitable with most electronic instruments.
Basic comps, PCB & chart **KIT 56-3 £11.22**
Text photocopy **TEXT 56 68p**
Knobs & sets **HW 56 £2.29**

P.E. SMOOTH FUZZ

Basic comps, PCB & chart **KIT 91-1 £6.52**
Text photocopy **TEXT 91 85p**
Knobs & sets **HW 91 £1.22**

EXPORT ORDERS ARE WELCOME but to avoid delay we advise you to see our list for postage rates. All payments must be cash-with-order, in Sterling by International Money Order or through an English Bank. To obtain list - Europe send 35p, other countries send 75p.
Note that we do not offer a C.O.D. service and that our terms are payment in advance.

PHONOSONICS · DEPT PE14 · 22 HIGH STREET · SIDCOT · KENT DA14 6EH

TERMS: C.W.O. MAIL ORDER OR COLLECTION BY APPOINTMENT (TEL 01-302 6184)

NO OTHER PROJECTS

PHOTOGRAPHS in this advertisement show two of our units containing some of the P.I.E. projects built from our kits and PCBs. The cases were built by ourselves and are not for sale, though a small selection of other cases is available.

LIST—Send stamped addressed envelope with all U.K. requests for free list giving fuller details of PCBs, kits and other components.

OVERSEAS enquiries for list Europe—send 35p; other countries—send 75p.



KIMBER-ALLEN KEYBOARDS AND CONTACTS

KIMBER-ALLEN KEYBOARDS as required for many published projects. The manufacturers claim that these are the finest moulded plastic keyboards available. All octaves are C to C, the keys are plastic, spring-loaded, fitted with actuators, and mounted on a robust aluminium frame.

3 Octave (37 notes) **£25.50** 4 Octave (49 notes) **£32.25** 5 Octave (61 notes) **£39.75**

CONTACT ASSEMBLIES (gold-clad wire) — 1 required for each KBD note:
Type GJ — SPC0 33p ea. Type BG — 2 p N/O 37p ea.

E. 6-CHANNEL MIXER

high specification stereo mixer with variable 1 impedances

asic comp. PCB & charts **KIT 90-8 £56.43**

extra 2-channel set with PCB **KIT 90-9 £10.21**

set of test photocopies **TEXT 80 £1.50**

no. sets, sw's See our list

RYTHM GENERATORS

rral available, including programmable 16 64000 pattern, and pre-programmed 15 em using either M252 or M253 rhythm chips. Selection of effects instruments circuits is also able.

IND & RAIN EFFECTS KIT

ighly modified version of the original P.E. unit. asic comp. PCB & chart **KIT 28-1 £4.84**

est photocopy **TEXT 8 £1.50**

no. sets, sw's **HW 28 £1.65**

E. ENVELOPE SHAPER WITH VCA

an integral Voltage Controlled Amplifier, and full manual control over the A.D.S.R. rations.

asic comp. PCB & chart **KIT 50-1 £8.03**

est photocopy **TEXT 50 £8p**

no. sets, sw's **HW50 £1.32**

E. TRANSIENT GENERATOR

ANSR envelope shaper without VCA, and tionally providing Repeat-triggering and ejection of notes to be programmed for mandolin o effects.

asic comp. PCB & chart **KIT 63-2 £7.62**

est photocopy **TEXT 63 £5p**

no. sets, sw's **HW63 £1.82**

E. EXTERNAL-INPUT SYNTHESIZER-INTERFACE

ives external inputs such as guitars, yphone etc., to be processed by synthesizer its.

asic comp. PCB & chart **KIT 81-1 £3.90**

no. sets, sw's **HW 81 £1.18**

E. TUNING FORK

uces B4 switch-selected frequency-accurate asings with an LED monitor clearly displaying eading adjustments.

et of basic comp., incl. power supply. **KIT 46-3 £23.32**

CBs & charts **TEXT 46 £8p**

est photocopy **TEXT 46 £8p**

no. sets, sw's **HW 46 £2.89**

E. TUNING INDICATOR

imple octave frequency comparator for use with esslers and other instruments where the full itality of KIT 46 is not required.

asic comp. PCB & chart **KIT 69-1 £8.19**

est photocopy **TEXT 69 £8p**

no. sets, sw's **HW 69 £1.56**

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& O.E. DELIVERY SUBJECT TO AVAILABILITY.

DIGITAL STEREO MIXER UNIT

ontrols up to 750 watts in $\frac{1}{2}$ second steps up to 10 minutes, with built-in auto alarm.

asic comp. PCBs **KIT 93 £23.45**

Text photocopy **TEXT 93 £1.20**

Knobs, skts, sw's **HW 93 £2.48**

P.E. DISCOSTROBE

A 4-channel light show controller giving a choice of sequential, random, or full strobe mode of operation.

asic comp. PCB & chart **KIT 57-3 £19.37**

Text photocopy **TEXT 57 78p**

Knobs, skts, sw's **HW 57 £7.30**

P.E. CONSTANT DISPLAY FREQUENCY COUNTER

A 4-digit counter for 1Hz to 99kHz with 1Hz sampling rate. Readout does not count visibly or flicker due to blanking.

asic comp. PCB & chart **KIT 79-4 £31.61**

Text photocopy **TEXT 79 78p**

Knobs, skts, sw's **HW 79 £4.67**

P.E. VOICE OPERATED FADER

For automatically reducing music volume during talkover — particularly useful for discos.

asic comp. PCB & chart **KIT 30-1 £4.37**

Text photocopy **TEXT 30 28p**

Skts **HW 30 32p**

P.E. DYNAMIC NOISE LIMITER

Very effective stereo circuit for reducing the hiss found in most tape recordings.

asic comp. PCB & chart **KIT 97-1 £8.07**

Text photocopy **TEXT 97 78p**

P.E. DYNAMIC RANGE LIMITER

Preset to automatically control output level.

asic comp. PCB & chart **KIT 62-1 £3.31**

Skts **HW 62 44p**

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DEVICE	PRICE	DEVICE	PRICE	DEVICE	PRICE
CPU's		74LS12	0.15	74LS378	0.73
6800	6.50	74LS13	0.15	74LS379	0.73
6801	3.82	74LS14	0.15	74LS386	0.29
6802	5.74	74LS15	0.15	74LS390	0.88
6803	14.53	74LS16	0.14	74LS393	0.81
6809	18.94	74LS21	0.15		
8085A	10.68	74LS22	0.15	CMOS	
Z80 CPU	8.84	74LS27	0.19	4000	0.14
Z80A CPU	8.23	74LS28	0.14	4002	0.14
SUPPORT CHIPS		74LS30	0.17	4006	0.85
6520	3.50	74LS32	0.14	4007	0.75
6522	6.50	74LS33	0.14	4008	0.29
6523	8.25	74LS38	0.17	4010	0.17
6821	1.93	74LS40	0.14	4011	0.47
6840	1.57	74LS42	0.14	4012	0.23
6850	1.36	74LS43	0.14	4013	0.72
6862	7.09	74LS47	0.42	4014	0.48
6871AIT	20.90	74LS48	0.70	4015	0.80
6880	1.07	74LS49	0.15	4016	0.68
6887	0.90	74LS51	0.14	4018	0.34
8212	0.77	74LS54	0.15	4019	0.75
8216	1.95	74LS55	0.15	4020	0.82
8224	4.20	74LS57	0.22	4021	0.88
8251	4.75	74LS57A	0.19	4022	0.84
8253	10.00	74LS75	0.30	4023	0.23
8255	4.80	74LS76	0.25	4024	0.19
Z80 CTC	5.78	74LS85	0.54	4025	1.28
Z80 DMA	17.62	74LS86	0.18	4027	0.85
Z80 DART	13.44	74LS90	0.31	4028	1.80
Z80A DART	16.44	74LS91	0.40	4033	1.70
Z80 P10	4.75	74LS93	0.40	4034	1.09
Z80 SIO-0	20.11	74LS96	0.48	4035	2.75
Z80 SIO-1	20.11	74LS108	0.26	4036	0.83
Z80 SIO-2	20.11	74LS112	0.26	4040	0.80
Z80A SIO-0	24.17	74LS113	0.26	4041	0.78
Z80A SIO-1	24.17	74LS114	1.07	4042	0.30
Z80A SIO-2	24.17	74LS122	0.45	4044	0.78
MEMORIES		74LS123	0.29	4045	1.70
2101	2.66	74LS124	0.35	4046	0.95
2102	2.54	74LS126	0.51	4047	0.34
2114 200ns	1.50	74LS132	0.29	4048	0.38
7008	0.29	74LS136	0.40	4049	0.77
7218 (5v)	3.35	74LS138	0.40	4050	0.78
7332	0.40	74LS139	0.40	4051	0.78
4116 150ns	1.60	74LS145	1.13	4052	0.78
4116 200ns	1.50	74LS146	0.35	4053	0.78
REGULATORS		74LS151	0.45	4054	1.23
7805	0.55	74LS152	0.36	4060	1.18
7812	0.65	74LS156	0.50	4063	0.46
7912	0.65	74LS157	0.36	4067	0.25
CRT CONTROLLERS		74LS158	0.40	4068	0.19
9384AP	8.64	74LS160	0.43	4070	0.29
6845	11.72	74LS161	0.43	4071	0.24
BUFFERS		74LS162	0.43	4072	0.24
81LS95	1.10	74LS164	0.51	4073	0.83
81LS96	1.12	74LS166	0.37	4074	0.29
81LS97	1.20	74LS173	0.78	4075	0.24
81LS98	1.25	74LS175	0.50	4076	0.83
81LS99	1.50	74LS176	0.61	4077	0.28
81LS99	1.50	74LS181	0.61	4078	0.24
81LS99	1.50	74LS190	0.61	4079	0.24
81LS99	1.50	74LS191	0.61	4082	0.57
81LS99	1.50	74LS192	0.61	4083	0.70
81LS99	1.50	74LS193	0.61	4093	0.53
81LS99	1.50	74LS194	0.42	4095	0.49
MISC. SUPPORT CHIPS		74LS195	0.42	4507	2.75
AY-3-1015	4.25	74LS196	0.68	4510	0.83
AY-5-1013	0.75	74LS197	0.68	4511	0.83
AY-5-2376	7.00	74LS201	0.64	4512	0.79
MC1488	0.45	74LS240	1.01	4514	2.88
MC1489	0.45	74LS241	1.15	4516	0.89
MC1441	8.00	74LS242	0.85	4518	0.89
MC1442	8.75	74LS243	0.85	4519	2.05
RO-3-2512L	7.82	74LS244	0.84	4520	1.90
RO-3-2513U	7.82	74LS245	1.21	4522	0.99
DATA CONVERTERS		74LS247	0.41	4523	1.15
ZN4A25E	3.50	74LS248	0.74	4524	1.45
ZN4A26E	3.50	74LS249	0.74	4525	1.45
ZN4A27E	3.50	74LS251	0.46	4526	1.45
ZN4A28E	3.50	74LS252	0.46	4527	1.45
ZN4A29E	3.50	74LS253	0.46	4528	1.45
ZN432	26.09	74LS257	0.87	4529	1.45
ZN433	22.69	74LS258	0.40	4530	1.45
Hand converter	1.00	74LS259	1.15	4531	1.45
74LS SERIES		74LS261	0.12	4532	1.45
74LS00	0.14	74LS262	0.25	4533	1.45
74LS01	0.15	74LS263	0.37	4534	1.45
74LS02	0.14	74LS264	0.45	4535	1.45
74LS03	0.14	74LS265	0.45	4536	1.45
74LS04	0.14	74LS266	0.45	4537	1.45
74LS05	0.15	74LS267	0.45	4538	1.45
74LS06	0.14	74LS268	0.45	4539	1.45
74LS07	0.14	74LS269	0.45	4540	1.45
74LS08	0.14	74LS270	0.45	4541	1.45
74LS09	0.14	74LS271	0.45	4542	1.45
74LS10	0.14	74LS272	0.45	4543	1.45
74LS11	0.15	74LS273	0.45	4544	1.45

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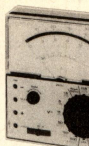
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**VALUE FOR MONEY
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- * 45 Ranges
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- DT-410 10MHz £169 + VAT
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- * CH1, CH2: 5mv/div - 20V/div in 12 cal steps.
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- * Size: H 215mm, W 165mm, D 280mm, Weight 4.5kg.

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- Z10 25 assorted presets, selenium etc. £1.30
- Z11 25 assorted var's and thermistors £1.45
- Z12 10 mixed hardware. Nuts, bolts, self-tappers, sleeving, etc. £1.30
- Z13 100 mixed and new marked, full spec. transistors. Pack includes:- BC148, BF154, BF274, BC212L, BC238, BC184L, PBC108 and, or lots of similar types
- Z14 100 mixed diodes including:- germanium, silicon etc. All full spec. £2.95
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- Z16 20 1N4148 £1.30
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- Z18 20 assorted zeners, 1 watt and 400mW £1.30
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- UHF MODULATORS**
Video in UHF out. Calibrated to channel 36 105 line UHF housed in metal box 2 1/2" x 3 1/2" with 9 coaxial lead, TV plug and connection data. £2.50 ea. 3 for £5.
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300 μ A Miniature lube/batt. meters, as fitted to many cassette recorders. 80p
- DELUXE FIBREGLASS printed circuit etching kits.**
Includes 100 sq. in. of copperclad FIB board, 1lb ferric chloride, (made for U.S. Army by MIL. SPEC.), 1 dialo etch resist pan, abrasive cleaner, tweezers, etch resist dish and instructions. £2.50 ea. 3 for £5.
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These cost a fortune! Were made for various music centres. Includes independent and interdependent latching types multi pole c/o etc. Can be modified. Can't be repeated. 3 Banks for £1.
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- PP3 Battery Connectors 10 for 50p.**
Miniature Press to Make Switches, Red knob. 3 for 50p.
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- 4 x HP11 Battery Holders (2 x 2 Flat type) with leads. 2 for 50p.**
- Assorted Fuse Holders including 20mm, P.C. Panel and chassis types. Pack of 7 for 50p.**
- 3mm Jack Sockets, switched. Enclosed type. P.C. or panel mounting. With nuts and washers. 4 for 50p.**
- 5 Section Chrome on Brass Telescopic Aerial. Plugs into any 3.5mm socket. Approx 25" extended £1 each. 3 for £2.50.**
- H. Power Infra. Red Transmitter 3mm LED. TIL 20 50p ea. 3 for £1.50.**
- Crystal Clear 3mm LEDs very pretty Red, Green, Yellow. 10 of one colour £1. 10 of each £2.50.**
- ALTERNATOR RECTIFIERS**
Make lovely 95 amp bridges. Ideal for High Power Battery Chargers. Type 4AFL. Set of 4 (2 neg. case + 2 pos. case) £2.
- Special Purchase enables us to offer Mullard C259 Polyester Capacitors (Liquorice Allsorts) at the unbeatable price of £2 for 100 mixed. £15 for 1000. These consist of factory clearance lots i.e. spillages, floor sweepings, cosmetic rejects etc.**

REMOTE CONTROL COMPONENTS AND KITS



LD271 IR Emitting diode	.36
SP4208 Photodiode Detector	.90
SL480 IC Pulse Amp	1.70
SA480 32 Channel Encoder/	
transmitter	2.40
ML480 32-channel receiver	
3-analog outputs	4.20

ML925. A decoder designed for model/toy control, providing a 2-speed drive motor and three position latched steering system or a vehicle with momentary action steering and a third motor, eg gun turret, winch, etc. Outputs also available for other functions such as horn, turn indicators, headlights, etc.

To make things **EVEN EASIER**, we have designed several new kits:—

MK6—Simple Infra Red TRANSMITTER. A Pulsed Infra Red source which comes complete with a hand held plastic box. Requires a 9V battery.

MK7—Infra Red RECEIVER. Single channel, range approximately 20 ft. Can be modified with a triac output to switch loads up to 500W at 240V ac, but can be powered for use with 5 to 15V dc supplies and transistor or relay outputs.

***Special Price *MK6 and MK7 together. Order as RC500K.**

MK8—Coded Infra Red TRANSMITTER. Based on the SL480, the kit includes 2 IR LEDs, measures only 8.2 x 1.3 cms, and requires a 9V (PP3) battery.

MK9—4-Way KEYBOARD. For use with the MK8 kit, to make a 4-channel remote control transmitter.

MK10—16-Way KEYBOARD. For use with the MK8 kit, to generate 16 different codes for decoding by the ML925 or ML926 receiver (MK12) kit.

MK11—10 On-Off Channel IR RECEIVER with 3 analogue outputs (0-10V) for controlling such functions as lamp brightness, volume, tone, etc. Other functions include an on/off relay output and a toggle output, which may be used for sound mixing. Based on ML922 decoder.

MK12—16 Channel IR RECEIVER. For use with the MK8 kit with 16 on/off outputs which with further interconnection, such as relay or triac, will switch up to 16 items of equipment on or off remotely. Outputs may be switched or momentary, depending on the version. The ML926 or ML928 is specified, includes its own mains transformer.

MK13—11-Way KEYBOARD. For use with MK8 and MK11 kits. Transmits programme step + and -, analogue + and - (3), mute normalise analogue outputs, on and standby.



ML926 16-channel receiver	4.40
ML928 16-channel receiver	4.40
ML929 16-channel receiver	4.40
IR LEDs	1.40
ICs on Plastic Receptor for	
CLIPs, increases range	20
2-speed drive	2.10

Our new TDR300K Touch Dimmer Kit will ensure that you are, at all times, in control of your highly sophisticated TDR300K touch controlled dimmer kit. The TDR300K kit incorporates an infra red receiver, enabling the lamp brightness to be varied and switched on or off by touch or remotely by means of a small hand held transmitter. The complete kit includes easy to follow instructions, will fit into a plaster depth box and the plastic front plate has no metal parts to touch, ensuring complete safety. Even a neon is included to help you locate the switch in the dark.



In years to come everyone will be selling remote control dimmers, but you can have your TDR300K kit now for **ONLY £14.30** for the dimmer unit and **£4.20** for the transmitter.



For the more athletic of you the TDR300K Touch Dimmer kit is still available at **£6.90** and the TDR300K kit now for **ONLY £14.30** for the dimmer unit and **£4.20** for the transmitter.

24 HOUR CLOCK/APPLIANCE TIMER KIT

DIGITAL VOLT/METER/ THERMOMETER KIT



Switches any appliance up to 1KW on and off at preset times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, 10-way relay, 2 switches, LEDs, triac, PCBs & full instructions.

CT100K Basic Kit	£14.90
CT1000KB with white box (561/31 x 71mm)	£17.40
Ready Built	£22.50

£19.50

Digital Voltmeter
Based on the AD7105. This kit contains a PCB, resistors, pre-set capacitors, diodes, IC and 0.5" liquid crystal display. Components are also included to enable the basic DVM to be modified to a Digital Thermometer using a single diode and the series resistor. 3mA 9V supply (PP3 battery).

DISCO LIGHTING KITS

Each unit has 4 channels (rated at 1KW at 240V per channel) which switch lamps to provide sequencing effects, controlled manually or by an optional opto isolated audio input.

DL1000K

This kit features a bi-directional sequence, speed of sequence and frequency of direction change being variable by means of potentiometer. Incorporates mirror dimming control.

DL121000K

A lower cost version of the above, featuring unidirectional channel sequence with speed variable by means of a preset pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum.

Optional Opto Input

DLA1

£6.00

MINI KITS

These kits form useful subsystems which may be incorporated into larger designs or used alone. Kits include PCB, short instructions and all components.

MK1: TEMPERATURE CONTROLLER/ THERMISTAT

1.5W £4

MK2: SMALL STATE RELAY

1KW £4

MK3: BAR/DOT DISPLAY

Displays an analogue voltage on a linear 10 element LED display as a bar or single dot. Ideal for thermometers, level indicators, etc. May be switched to obtain a 100 element display. Requires 5-20V supply.

MK4: PROPORTIONAL TEMPERATURE CONTROLLER

Based on the TL1024 2.0V voltage switch, this kit may be wired to form a "burst fire" power controller enabling the temperature of an enclosure to be maintained to within 0.5°C.

MK5: MAINS TIMER

Based on the ZN1034E Timer IC this kit will switch a mains load on for a preset time from 20 minutes to 35 hours. Longer or shorter periods may be realised by minor component changes. Maximum load 1KW.

BOXES

Moulded in high impact ABS. Supplied with 6 pins and screws. Black.

B1 75 x 6 x 35mm

B2 75 x 11 x 35mm

B3 115 x 9 x 37mm

85p

95p

10p

ZENER DIODES

1W 10 ohm-10M.

£12 series.

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100k 100V (one package)

100k 100V (one package)

100k 100V (one package)

100k 100V (one package)

100k 100V (one package)

100k 100V (one package)

100k 100V (one package)

INTEGRATED CIRCUITS

555 Timer

741 Op Amp

AY-5-1234 Clock

AY-5-1270 Thermistor

CA3080 Transconductance Op. Amp.

CA3130 CMOS Op. Amp.

ICL7106 DVM (LCD Drive)

LM339 Dual 4V Amp.

LM3795 Dual 6V Amp.

LM380 2W Audio Amp.

LM392 4W Audio Amp.

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EVERY DOOR SHOULD HAVE ONE

Whatever kind of door you have, our New Electronic Combination Lock will enable you to open it easily but make things very difficult for unwelcome visitors. The unit, which comes complete with a 10-way relay, requires an easily remembered four digit code to be entered before the door can be opened, whereby the intruder has over 5,000 combinations to choose from. The code can be easily changed by means of a pre-wired plug and a momentary or latched output version can be made. The kit has even more uses in a car where it may be used to disable the ignition. Another useful feature is the Save Button. This stores the combination number, enabling the car to be used by authorised persons such as garage personnel without needing the code. The combination measures 7.6 x 3 cms. deep and consumes a mere 40uA when in use, and will drive a 15V (750mA) solenoid or relay coil (not supplied) directly. So why not treat your door to a new lock for **ONLY £15.50** and think about all the keys you can lose or forget without ever locking yourself out. (As featured in P.M. May '81)

TRIACS

400V Plastic Case (Texas)

3A TIC206D

8A TIC226D

12A TIC236D

15A TIC246D

25A TIC263D

6A with trigger GA0061T

8A isolated tab TIALX226B

10A

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

10p

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10p

555 Timer

741 Op Amp

AY-5-1234 Clock

AY-5-1270 Thermistor

CA3080 Transconductance Op. Amp.

CA3130 CMOS Op. Amp.

ICL7106 DVM (LCD Drive)

LM339 Dual 4V Amp.

LM3795 Dual 6V Amp.

LM380 2W Audio Amp.

LM392 4W Audio Amp.

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4K Expansion (8x2114)
NOW ONLY £14.00

No extras required

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- ★ 8K basic incl garbage collection routine
- ★ Ram expandable to 8K on board (4K inc)
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- ★ NEW MONITOR ALLOWS FULL EDITING & CURSOR CONTROL **NOW INCLUDED IN KIT**

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Available for U.K.
101, Superboard
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DIM. 17" x 15"
435 x 384 mm.

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Post + Packing
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UK101 MEMORY BOARD

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- ★ Fully buffered for expansion via 40 pin socket
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8K Kit (inc. 16K skts) **£79.95**. 16K Kit **£106.95**
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UK101 AND SUPERBOARD COMPATIBLE.

Interfaces to GP80, MX80 series, TX80, centronics P1, etc printers. Can operate relays, motors, various other peripherals. LED binary display. Plugs into ACIA socket. Fully documented.

Built and tested.

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9 x 9 dot matrix, 80 c.p.s. True descenders. various print densities up to 132 columns, tab controls both horizontal & vertical, bold expanded condensed printing, bidirectional.

EPSON MX80 FT/1 £399

Dual single sheet friction and continuous tractor feed, 9 wire head, true descenders.

EPSON MX80 FT/2 £449

Additional feature to FT/1 is high resolution graphics.

EPSON MX70 £259

Tractor feed, 7 wire head, high resolution graphics.

SEIKOSHA GP80A £199

Dot matrix 5 x 7, 80 columns, 30 cps, graphics, double width characters.

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VIDEO GENIE
based on TRS80

Utilises Z80, 12K level II Basic, Integral Cassette Deck, UHF O/P, 16K RAM, all TRS80 features. Simply plugs into monitor or UHF TV with VU meter.

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UK101 SOUND

Sound generator and combined parallel in out port containing P.C.B., AY-3-8910, 6520 PIA, fully documented and demo tape.

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AY-3-8910

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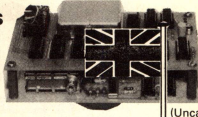
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(Uncased)

Includes full documentation and demonstration tape.

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Please add VAT 15% to all prices. Postage on computers, printers and cassette decks charged at cost, all other items, P&P 30p. Place your order using your Access or Barclaycard (Min. tel order £5). Trade and export enquiries welcome. Official orders welcome.





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4008 8K RAM
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The new PET printer,
 4022 80 column tracks feed.
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 For the business man we
 stock the 8000 range inc.
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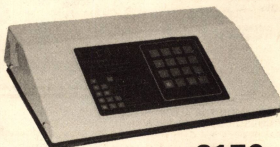
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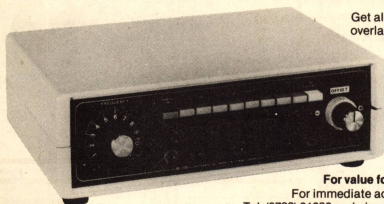
Ask Prestel a question and you have
 your answer in seconds in full colour on
 your own TV. Only requires a telephone
 jack socket available from the PO.



£170

Tanel is Post Office approved.
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The 2001 sweeps the board at only £78*



Get all the waveforms you need - 1 Hz to 1 MHz in five
 overlapping ranges: stable, low-distortion sine waves,
 fast rise/fall-time square waves, high linearity
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 wave output. Plus high- and low-level
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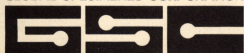
An applied DC Voltage at the Sweep input
 can shift the 2001's frequency: or sweep
 up to 100:1 with an AC signal.
 A pushbutton activates the DC Offset control,
 which shifts the output waveform up
 or down on command.

For value for money the 2001 sweeps the rest off the board.

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New! Sinclair ZX81 Personal Computer. Kit: £49.⁹⁵ complete

**Reach advanced
computer comprehension
in a few absorbing hours**

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. At £99.95, the ZX80 offered a specification unchallenged at the price.

Over 50,000 were sold, and the ZX80 won virtually universal praise from computer professionals.

Now the Sinclair lead is increased: for just £69.95, the new Sinclair ZX81 offers even more advanced computer facilities at an even lower price. And the ZX81 kit means an even bigger saving. At £49.95 it costs almost 40% less than the ZX80 kit!

Lower price: higher capability

With the ZX81, it's just as simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, or to select a program off a cassette through the keyboard.

Higher specification, lower price – how's it done?

Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

Proven micro-processor, new 8K BASIC ROM, RAM – and unique new master chip.

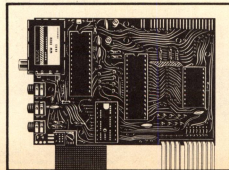
**Built:
£69.⁹⁵
complete**



Kit or built – it's up to you!

The picture shows dramatically how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



New Sinclair teach-yourself BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs. You need no prior knowledge – children from 12 upwards soon become familiar with computer operation.




```

IF J=N THEN GO TO 5
TO N
=1(X)

J=N THEN GO TO 45
41(J)A(I) THEN GO TO
(J)
=2(T)
= P
THEN GO TO 15

```

Improved specification

20A micro-processor - new faster version of the famous Z80 chip, widely recognised as the best ever made.

- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.

- Unique syntax-check and report codes identify programming errors immediately.

- Full range of mathematical and scientific functions accurate to eight decimal places.

- Graph-drawing and animated-display facilities.

Multi-dimensional string and numerical arrays.

Up to 26 FOR/NEXT loops.

Randomise function - useful for games as well as serious applications.

Cassette LOAD and SAVE with deleted programs.

16K-byte RAM expandable to 16K with Sinclair RAM pack.

able to drive the new Sinclair printer (available yet - but coming soon!)

Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip unique, custom-built chip replacing ZX80 chips.

sinclair ZX81

Sinclair Research Ltd,
Rings Parade, Cambridge, Cambs.,
21SN. Tel: 0276 66104.
Fax: 0276 66105.
Tel: 0214 4630 00

If you own a Sinclair ZX80...

The new 8K BASIC ROM used in the Sinclair ZX81 is available to ZX80 owners as a drop-in replacement chip. (Complete with new keyboard template and operating manual.)

With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 - including the ability to drive the Sinclair ZX Printer.

Coming soon - the ZX Printer.

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics across 32 columns, and highly sophisticated graphics. Special features include COPY, which prints out exactly what is on the whole TV screen without the need for further instructions. The ZX Printer will be available in Summer 1981, at around £50 - watch this space!



16K-BYTE RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.



How to order your ZX81

BY PHONE - Access or Barclaycard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST - use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access or Barclaycard.

EITHER WAY - please allow up to 28 days for delivery. And there's a 14-day money-back option, of course. We want you to be satisfied beyond doubt - and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST 7, Cambridge, CB21YY.

Qty	Item	Code	Item price £	Order Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack(s).	18	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

Please tick if you require a VAT receipt ☐

*I enclose a cheque/postal order payable to Sinclair Research Ltd, for £

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*Please delete/complete as applicable.

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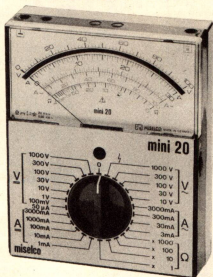
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20k Ω /V d.c. 6.6k Ω /V a.c.

multimeter

only £19.50
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The Mini 20 is an ideal instrument for the constructor. This special offer is a wonderful opportunity to acquire an essential piece of test gear with a saving or nearly £10 on the normal retail price.

The 26 ranges cover all likely requirements. Operation is straight-forward, just turn the selection switch to the required range.

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d.c.I: 50 μ A, 1mA, 10mA, 100mA, 1A, 3A.
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Movement protected by internal diode and fuse.
The instrument is supplied complete with case, leads and instructions.

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3 CHANNEL SOUND/LIGHT CHASER

LB31000SLC

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A high performance sound to light system which automatically switches to a chase when the music ceases. Super sensitive with an anti interference circuit, the unit will operate from practically any amp and control up to 1.000W/channel. 5Hz to 70K. Controls: bass/mid/treble/master sensitivity/chase speed.

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£22.70

All the advantages of the SLC without chase. Controls: bass/mid/treble/master sensitivity.

2/4/8 CHANNEL CHASER

LB1000LC



£28.00

An all logic chaser system for use with up to 8 channels at 1,000 watts each. Facilities include tonewhich trigger and module cascading (16, 24, 32 channel, etc.), chase speed and re-cycle delay.

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£19.20

A 4 channel sequence generator for banks of lamps up to 1,000W per channel. Two speed controls, cross effect to provide settings between seconds and rapid burst.

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Power dimmer units for theatre/stage applications up to 1,000W per channel, with on board suppressing. The unit is also available without rotary pots for use with sliders —

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4 colour

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A four channel chaser up to 1,000W per channel, with a sound trigger facility. The music input signal modulates the speed of the chase giving an excellent sound/light effect. The unit will control up to 10 ropes with chase speed and trigger level control.

Each module is manufactured from the highest quality components, fully tested, supplied with a connection and circuit diagram and guaranteed for twelve months.

All prices shown are VAT inclusive. Please include 50p post/packing except where indicated. Tested to mail order send cheque/P.O. registered cash or Access market. C.O.D. please add £1 extra. For our catalogue/specifications send 50p.

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LBPA3

M - Magnetic
C - Ceramic

£33.70

Magnetic or ceramic deck versions - please state

All the requirements of a stereo disco preamp on one board, left and right deck mixers/tone controls, microtonal/mic, auto fade over decks and P.F.L. The unit can be used with LB1000SLC.

Full set of pots — £8.63

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A four channel mixer and tone stage for mics, guitars, etc. Can be used with any LB amps.

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A stereo hi-fi preamp and tone stage for mics, guitars, etc. Can be used with any LB amps.

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LBACO1

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Active crossover with stage booster! Available with crossover points of 200 or 300Hz, and 2X or 3X (please specify) LBPSU1 supply for LBACO1, 11 or 21.

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Bass/mid/treble active crossover with stage booster! Available with crossover points of 200 or 300Hz, and 2X or 3X (please specify) LBPSU1 supply for LBACO1, 11 or 21.

Tough etching power-amps for use in sound systems. Open/short circuit protection and fused. Heavy gauge heatrinks and rugged up/down devices (all operate down to 4 ohms).

25W R.M.S. | 10W R.M.S. | 50W R.M.S. | 270W R.M.S.
20k to 80k | 5k to 25k | 5k to 25k | 5k to 25k
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A de-thumping unit for use with any LB power amps.

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NEW — MINI MODULES — NEW

Ingeniously designed mini pre-amplifier building blocks for use in music and P.A. applications. You choose the type and number of units you require for your particular system and mount each module via its control direct onto your panel.

LBMM1 Pre-amp for mics, guitars etc.
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LBPSU1 + 15V supply for up to 12 modules.

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Discount on MM1/2/3/4/5 10 to 24 — 20%, 25+ — 30%.

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125 WATT MODEL **£10.50** plus £1.15 p&p (Illustrated)

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SPECIFICATIONS

Max. Output power 125 watt RMS
Operating voltage (DC) 50-80 Max.
Leads 50-80 Max.
Frequency response measured at 100 watts 25Hz-20KHz
Sensitivity for 100 watts 400mV @ 47K
Typical T.H.D. @ 50 watts 4 ohms load 0.1%
Dimensions 205 x 90 and 190 x 36 mm

The P.E. power amp kit is a module for high power applications—disc units, guitar amplifiers, public address systems and even high powered systems. The unit is protected against short circuiting of the load and is safe in an open circuit condition. A large safety margin exists by use of generously rated components, result, a high powered rugged unit. The PC Board is backprinted, etched and ready to drill for ease of construction, and the

aluminium chassis is preformed and ready to use. Supplied with all parts, circuit diagrams and instructions.

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PRACTICAL ELECTRONICS CAR RADIO KIT (Constructors pack 7)



2 WAVE BAND MM LW
* Easy to build * 5 push button tuning
* Modern styling design * All new unused components
* 6 watt output * Ready etched & punched P.C.B.
* Incorporates suppression circuits * Now with tape input socket

All the electronic components to build the radio, you supply only the wire and solder as featured in the Practical Electronics March issue. Features: Pre-set tuning with five push button options, black illuminated tuning scale, with matching rotary control knobs, one, combining on/off volume and tone-control, the other for manual tuning, each set on wood simulated fascia. The P.E. Traveller has a 6 watts output, neg ground and incorporates an integrated circuit output stage, a Mullard IF module (LP1183) ceramic filter type, pre-aligned and assembled and a Bird pre-aligned push button tuning unit. The radio fits easily in or under dashboards.

Complete with instructions.

£10.50

CONSTRUCTORS PACK 7A

Stainless steel fully retractable locking metal and speaker (approx. 6" x 4") in. per pack available as a kit complete **£1.95** p&p £1.15



30 + 30 WATT STEREO AMPLIFIER BUILT AND TESTED

Vicount V 10 in teak simulate cabinet silver finished rotary controls and pushbuttons with matching fascia, red main indicators and stereo jack socket. Functions switch for mic magnetic and crystal pickups, tape and auxiliary. Rear panel features five holder. DIN speaker and input socket 30 + 30 watts. RMS 60 + 60 watts peak for use with 4 to 8 ohm speakers. Size 14cm" x 10" approx.

READY TO PLAY **£32.90** plus £3.80 p&p

HI FI STEREO AMPLIFIER MODULES

- Mullard (LP1183) built preamplifier suitable for ceramic and auxiliary inputs. **£1.95** plus 70p p&p
- Mullard (LP1184) built preamplifier suitable for magnetic/ceramic and auxiliary inputs. **£4.95** plus 80p p&p
- Matching I.C. 10 + 10 Stereo Power amplifier kit. **£2.95** plus £1.15 p&p
- Matching power supply kit with transformer. **£3.90** plus £1.98 p&p
- Matching set of 4 slider controls complete with knobs for bass, treble and volumes. **£1.70** plus £0.80 p&p
- Complete with application notes.

10+10 WATT STEREO AMPLIFIER KIT

- Featuring latest SGS/ATES TDA 2006 10 watt output I.C.'s with in-built thermal and short circuit protection.
- Mullard Stereo Preamplifier module.
- Attractive black vinyl finish cabinet. Size 9" x 8" x 3 3/4" approx.
- Converts to a 20 watt Disco amplifier.

To complete you just supply connecting wire and solder. Features include din input sockets for ceramic cartridge, microphone, tape or tuner. Outputs—tape, speakers and headphones. By the press of a button it transforms into a 20 watt disco amp with twin deck mixing. The kit incorporates a Mullard (LP1183) pre-amp module, plus power amplifier assembly kit and mains power supply. Also featured 4 slider level controls, rotary bass and treble controls and 6 push button switches. Silver finish fascia panel with matching knobs and contrasting red made black vinyl finish cabinet and ready made metal work. For further information instructions are available price 50p. Free with kit.

SPECIFICATIONS

Suitable for 4 to 8 ohm speakers
Frequency response 40Hz - 20KHz
Input Sensitivity P.U. 150mV Aux. 200mV Mic. 1.5mV
Tone controls Bass $\pm$ 12dB @ 60Hz
Treble $\pm$ 12dB @ 10KHz
-1% typically @ 4 watts
220-250 volts 50Hz

BSR chassis record deck with manual set down and return, complete with stereo ceramic cartridge. **£5.50** plus £3.15 p&p when purchased with amplifier.

Available separately **£10.50** plus £3.16 p&p.

8" SPEAKER KIT $\pm$ 8" approx. twin cone domestic use speakers. **£4.75** per stereo pair plus £1.70 p&p when purchased with amplifier. Available separately **£6.75** plus £1.70 p&p.

STEREO MAGNETIC PRE-AMP CONVERSION KIT

All components including P.C.B. to convert your ceramic input on the 10+10 amp to magnetic. **£2.00** when purchased with kit featured above. **£4.00** separately inc. p&p.

RTVC
323 EDGWARE ROAD, LONDON W2
21 B HIGH STREET, ACTON W3 6NG

ACTON: Mail Order only. No callers
ALL PRICES INCLUDE VAT AT 15%
All items subject to availability. Price correct at 1/4/81 and subject to change without notice.

For further information send for instructions 20p plus stamped addressed envelope.

NOTE: Goods despatched to mainland and N. Ireland only. Persons under 16 years not served without parent's authorisation.

RTVC LTD. reserve the right to alter, update or improve their products without notice.

MULLARD LP1183 STEREO PREAMP

FREE! Original listed price over £5.00. Suitable for ceramic and auxiliary inputs, when you purchase 2 power module kits.



STEREO DISCO PREAMPLIFIER

Matching above modules, suitable for twin deck mixing with P.F.L. output and Mic/Tape input. Ready built, ready to play with circuit diagram and application notes to suit our power module kits.

£21.95 plus £1.72 p&p

100 WATT MONO DISCO AMPLIFIER

Brushed aluminium fascia and rotary controls. Size approx 14" x 4" x 10 1/4". Five vertical slide controls, master volume, tape level, mic level, deck level, PLUS INTER DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Five fade level controls (PUL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.

£76.00 plus £4.00 p&p

50 WATT MONO DISCO AMPLIFIER

Size approx 13 1/2" x 5 1/2" x 6 1/2". 50 watts RMS 100 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

£30.60 plus £3.68 p&p

BSR Manual single play record deck with auto return and cueing lever. Fitted with stereo ceramic cartridge 2 speeds with 45 rpm spindle adaptor ideally suited for home or disco use.

£12.25 OUR PRICE plus £3.16 p&p

PHILLIPS RECORD PLAYER DECK GC037
Size approx 15 1/2" x 12 1/2"

Hi Fi record player deck, 2 speed, damped cueing, auto shut-off, belt drive with floating sub chassis to minimise acoustic feedback. Complete with GP401 stereo magnetic cartridge—LIMITED STOCK. UNBEATABLE OFFER AT

£27.50 complete plus £3.16 p&p

JAPAN — 10 YEARS AHEAD

NO the Japanese are not 10 years ahead in technology; we're talking about how they see their electronics industry in the next 10 years with regard to prospects, technological development and product demand — not a bad thing to investigate with most of the world in the midst of an economic depression. A 626 page report by the Japanese Electronic Industry Development Association has been published by the Fuji Corporation and is available at a cost of \$400. We have seen a summary of it which makes interesting reading for anyone concerned with electronic technology in the UK and the rest of the world.

Having analysed the present aspects and trends the report provides a proposition of seven points for the future direction of the electronics industry in Japan. It is these seven points that show the way ahead, not only for Japan but for the rest of us.

They are: technological results are producing great ripple effects on other industries and form the core of innovations that will push the Japanese in-

dustrial structure to further heights. Consequently, the importance of the electronic industry should be recognised and efforts for its development undertaken.

In the 1980s, a time when low economic growth, resource conservation and energy-saving are taking hold, efforts will need to be redoubled to firmly establish the electronic industry's position as a key industry of Japan by fully utilising the special characteristics of the industry and at the same time to accelerate technological development.

While industry efforts will need to be channelled in basic research and development, there is an urgent need at national level for a clarification of research and development guidelines, appropriate financing and tax relief measures, systemising of the research and development programs, and furthering of co-operative and assistance arrangements.

From an international perspective, there will need to be a promotion of foreign trade activities, capital investment, industrial penetration into over-

seas markets, and technological transfer. It is imperative that efforts be made to respect the position of each foreign country and work out rules for mutual reconciliation.

Since the importance of software within the computer industry will continue to rapidly increase in the future along with the upgrading of hardware, efforts will need to be made to put software production on a more efficient basis.

For the private enterprises, there is an urgent need for in-company technical training, training for jobs in other fields and retraining for improving present skills.

In connection with the development of technology application, there is a need to undertake assessment in the practical application of technological development, and to eliminate any negative aspects that arise.

If the Japanese implement these suggestions and we simply sit back, where will we be in 10 years?

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Technical Queries

We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in Practical Electronics.

All letters requiring a reply should be accompanied by a stamped, self addressed envelope and each letter should relate to **one published project only.**

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers

Copies of some of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders

Binders for PE are available from the same address as back numbers at £4.30 each to UK or overseas addresses, including

postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions

Copies of PE are available by post, inland or overseas, for £11.80 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...NEWS &

Edited by David Shortland
& Jasper Scott

VIDEODISCS set for take off

The video market, which has continued to expand with the sale of video recorders increasing despite the recession will be further strengthened in the coming year with the introduction of video disc systems.

These systems are designed to playback pre-recorded programs stored on discs, with typical playback times of two hours.

Three companies are planning videodisc launches with Philips leading the way later this year with their LaserVision system followed by Thorn and RCA in 1982. The RCA Selecta Vision system launched recently in the USA amid a \$20 million advertising campaign uses Capacitive Electronic Disc (CED) technology which combines a diamond micro-stylus with a conductive grooved disc. The Philips Laservision is an optical system which uses a light beam instead of a stylus to read the disc, whilst the Thorn system developed by JVC also uses the CED system but with smooth discs which enables the stylus to be easily moved across the disc. The pick-up head also includes an automatic tracking signal which ensures the head is correctly aligned on the disc during playback.

Once again as with VCR systems, these three disc systems are not compatible.

Fibre Optic TV

Strands of glass fibre, no thicker than a human hair, will be relaying television and radio programmes to 18 households in Milton Keynes by the end of this year.

The rental houses, at Oldbrook 1 near the city centre, have been chosen by British Telecom for their first public trials of transmitting TV programmes by fibre optic cable. A single fibre optic cable can carry as much information as a copper co-ax cable but is physically smaller.

Electrical signals, converted into pulses of light, will be carried over one optical fibre cable from the receiving station at Linford Wood to a distribution point near the houses.

From that point, smaller optical fibre cables will be laid to each house where the signals will be converted back into an electrical form suitable for reception on ordinary TV sets and radios.

The trial will be monitored by British Telecom for at least one year and there will be no additional costs involved for either the Milton Keynes Development Corporation or the residents.

BIRD BARGAIN

A car radio/cassette listed by Bird Audio in January 1980 at £180 plus VAT is now available for just £65.95 including VAT. The radio/cassette is the 8020 Combination Unit MW/VHF stereo radio and stereo cassette player with automatic eject. The radio has a digital frequency readout with pushbutton two level (local or distant stations) autosearch in either direction or manual tuning with single memory. The unit also incorporates a 24 hour digital clock with continuous display at ignition on or 15 second selectable display while the radio is on. The set employs the patented Philips/IAC interference suppression circuitry, has a mono/stereo reception switch, interstation muting and boasts 7 watts per channel output.

Other features include MW/VHF and stereo indicators, tone, balance and volume controls, clock set buttons and locking fast forward and rewind cassette switch. The output stages are neatly housed in a separate black steel enclosure. The set comes with inter-connecting leads and full installation instructions. One of the most comprehensive units around and not to be missed at this price. Limited quantities available to callers only (not mail order) from RT-VC, 323 Edgware Road, London W2.

Also available is the 7300 combination unit—basically the same without the digital clock and frequency readout, but including LW and I.e.d. station indicator. Previously listed by Birds at £156 plus VAT, now £53.95 inclusive from RT-VC, again limited quantities to callers only.

COMPONENT CATALOGUE

T&J Electronic Components, who specialise in Mail-Order, have recently published their latest catalogue, which is packed with electronic components and accessories. It is available to readers at a price of 45p, including postage.

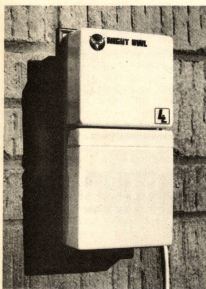
T&J Electronic Components, 98 Burrow Road, Chigwell, Essex. (01-500 7073)



MARKET PLACE

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

NIGHT OWL



Night Owl is a radar controlled courtesy light and intruder detector which can protect an egg shaped area with a forward range of 100 feet.

When the radar system detects a moving vehicle or person the house lights are automatically turned on. These lights stay on for an adjustable time period after the last movement has ceased. However if further movement is detected the lights will come back on. The unit is programmed to accept only continuous movements, an anti-flutter system rejects momentary and oscillatory movements (i.e., doors, curtains, trees etc.).

The detection range is adjustable from 6 to 100 feet and the light duration can be set from $\frac{1}{2}$ to 10 minutes. (If an audible alarm or extra light is required an extra set of contacts are built into the unit).

The unit which is priced at £150 is available from Loadpoint Ltd., Chelworth Industrial Estate, Cricklade, Swindon, Wilts.

SONY BETASTACK

The latest addition of Sony's range of high-quality video equipment is the Betastack — a video cassette autochanger which was recently introduced to the public at the Home Video Show.

The Betastack enables the Sony C7 video recorder to provide up to 13 hours of unattended recording. Because the C7/Betastack combination can be programmed to automatically record up to four TV programmes onto four separate cassettes of appropriate length, the user can conveniently record over tape no longer required yet save those programmes he wishes to see again. This added convenience also helps ensure the most cost-effective use of video tape.

The Betastack can be fitted to the C7 recorder by a Sony dealer (though some early machines may require minor adaptation), and new purchasers of the C7 recorder will be able to obtain the advantages of Betastack already fitted for £129.00. Supply and fitting to existing owners' C7 recorders will cost under £150.

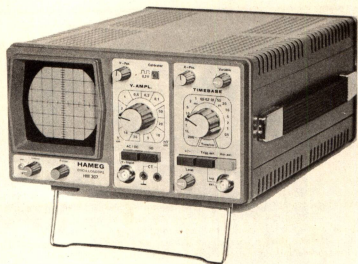
CHIP SHOP KITS...

An entirely new range of practical, easy-to-solder electronic kits, all retailing at £5.00 or less, will soon be available from High Street hobby shops. Called Chip Shop Kits, there are over 20 different electronic projects in the range, which have been specifically designed to introduce teenagers or adults to the world of electronics.

Each Chip Shop Kit contains all the components necessary to build the project described. All that is needed is a soldering iron and a 9 volt battery to power the circuit. Step-by-step instructions on construction are included in the box together with detailed educational notes about the individual circuit and advice about soldering techniques, with particular reference to safety precautions. All components are guaranteed. Projects currently available include a burglar alarm, electronic organ, lie detector, two transistor radio and a soldering iron.

Electroni-Kit Ltd., Rectory Court, Chalvington, Hailsham, East Sussex. (032 183 579).

NEW HAMEG 'SCOPE



The HM307 from Hameg is a lightweight single trace scope which has been designed for both the service technician and the advanced hobbyist. A principle feature of the HM307 is its built-in component tester. This allows both passive and active components to be tested while still in circuit. Operation of the component tester is activated by push-button and during the test operation it is not necessary to change the oscilloscope settings.

If the component under test has a very high resistance or is open circuit, then the display is in the form of an almost horizontal line and a short circuit across the test terminals results in a vertical line. Medium resistances are indicated by a diagonal line on the screen.

Capacitors and inductors exhibit a phase differential between X and Y deflections giving an elliptical display. Because of the low frequency of the test signal (50MHz) only relatively large capacitors and inductors will exhibit this phase difference: capacitors between 10nF and 100µF.

The HM307 is priced at £138 plus VAT and p.p. Hameg Ltd., 74-78 Collingdon Street, Luton, Beds (0582 413174).

OK SOURCE



OK Machine & Tool's new battery charger will charge three different sizes of Ni-Cad battery—HP7, U11 and U2. Two or four batteries can be charged at a time, and any pair of same-sized batteries can be fitted in one section, with another pair of different sized batteries in the other section. Charging times range from 10 to 16 hours.

Another new product from OK is their Economy PCB Repair Kit, which they claim will pay for itself very quickly—after a few 'on the spot' salvage jobs. The kit includes master frames with tracks and fingers, eyelets and eyelet setting tools.

The Ni-Cad Battery Charger is priced at £11.38, and the Economy PCB Repair Kit at £46.80. Both prices are exclusive of VAT and p.p.

OK Machine & Tool (UK) Ltd, Dutton Lane, Eastleigh, Hants. (0703 610944).

POINTS ARISING . . .

DP200 MULTIMETER (May '81)

Please note: The price given for the complete kit of parts for the DP200 excludes the price of the case and LE-DPM200 panel meter.

MASTER RHYTHM (Jan '81)

In Fig. 7 C53 should connect to R49/59/69/79. The p.c.b. and overlay are correct.

MICROTUNE (Dec. '80 & Jan. '81)

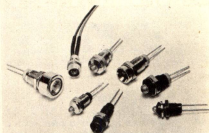
R19 should be 220k, R42 should be 10k and R43 should be 10k.

The second R42 shown on the circuit diagram as a 2k2 and missing on the component overlay, is unnecessary. This component may be ignored. R44 should be 220k. Resistors which appear in the components list only, may be ignored.

GRAPH DISPLAY UNIT (March '81)

The capacitor C4 should connect from pin 6 to pins 1/2. C3 from 3 to 4/5.

LIGHTING-UP



West Hyde Developments, who are well known for their 'Bocon' range of cases, have now introduced a wide range of l.e.d.s manufactured by the German company Mentor.

The l.e.d.s are available in sizes of either 3mm or 5mm diameter, with a choice of four colours. There is also a choice of concave or convex reflectors finished in chrome or black.

In addition to this standard range, there is also a range of flashing variants with built-in circuitry. At the top of this range is an l.e.d. which provides either a continuous green or flashing red light.

For further details contact West Hyde Developments Ltd, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks. (0296 20441).

MARKET PLACE

Home Office in trouble with ASA

The Home Office has been in trouble with the Advertising Standards Authority who received a complaint concerning the national TV licence campaign. The complaint centred around the statement in the advertisement, 'If you own a TV set, you're actually required by law to own a licence', which is incorrect.

If you only use your TV for showing pre-recorded video programmes or for playing video games, then you're not required by law to own a licence. The Home Office gave an undertaking to clarify the legal situation in future advertisements.

PCB PINNING TOOL



A new hand tool has been developed for the quick and easy insertion of strip form track pins which enable double sided p.c.b.s. to be interconnected without the need for plated through holes.

The new tool feeds out the strip form track pins, exposing them one at a time so they are ready to be located in the p.c.b. hole. When the pin has been located correctly, it is broken off the strip, leaving it in place in the hole, ready for soldering. At the press of a button, the tool exposes another pin and the process is repeated in the next hole to be connected through.

Apart from making the pin insertion process a lot quicker and easier, the new tool also ensures consistent insertion of the pin. Until now, the normal method of using the pins in strip form has been by holding the strip in the fingers. Another advantage of the new method is that the pins are kept clean during assembly prior to soldering.

The price of the tool is £25 excluding VAT and p&p, and it is available from Harwin Engineers, Fitzherbert Road, Farlington, Portsmouth, Hants. (0705 370451).

Countdown...

Entertainment postponed.

Welsh Amateur Mobile Rally May 10. Barry Memorial Hall. **C**
Defence Components Expo May 12-14. Metropole, Brighton. **I**
East Suffolk Wireless Revival May 24. Civil Service Sports Association, Sports Ground, Straight Road, Ipswich. **V1**
Hobby Electronics May 29-31. Bristol Exhibition Centre. **B7**
Scotex June 2-4. Royal Highland Exhibition Hall, Ingleston, Edinburgh. **A1**

Semlab June 2-5. Grand Hall, Olympia, London. **I**
Electronic Hotel June 3-4. West Centre Hotel, Fulham, London. **Z1**
Viewtext June 4. Europa Hotel, London W1. **Z1**
Transducer/Tempon June 9-11. Wembley Conf. Centre, London. **T**
Components June 9-12. Earls Court, London. **I**
Pet Computer Show June 18-20. West Centre Hotel, London. **B8**
Compe North June 23-25. Belle Vue Hotel, Manchester. **Z1**
International Word Processing Exhibition & Conf. June 23-26. Wembley Conf. Centre, London. **Z**
Leeds Electronics Show June 30-July 2. University of Leeds. **E**
Nat. Education & Training (Exhibition & Conf.) July 2-4. NEC, Birmingham. **B2**
BEX Portsmouth July 15-16. Centre Hotel. **K**
BAEC Amateur Electronics Exhibition July 18-26. The Shelter Penarth Esplanade, S. Glam. **B9**
Microcomputer Show (and seminars) July 29-31. Wembley Conf. Centre. **O**

Solar Energy Exhibition August 23-28. Brighton. **M**
Harrogate Int. Fest. of Sound August 15-18. Royal Hall Exhibition Centre & Hotels. **X**
BEX Cardiff September 3-4. Centre Hotel. **K**

Business & Light Aviation September 3-5. Cranfield Airport. **Z1**
Microprocessor Workshop September 7-8. University of Liverpool. **D**
Laboratory September 8-10. Grosvenor House, Park Lane, London. **I**
Personal Computer World Show September 10-12. Cunard Hotel, London. **M**

West of England Electronics Show September 15-17. Bristol Exhibition Centre. **Q**

Business Telecoms & Electronic Office September 23-25. Royal Lancaster Hotel, London. **O**

BEX Edinburgh September 30-October 1. Assembly Rooms. **K**

Viewdata October 6-8. Wembley Conf. Centre, London. **O**

BEX Bristol October 14-15. Exhibition Centre. **K**

- C** Barry College of Further Education Radio Society. £ 0222 565656
- D** Brownlow Hill, PO Box 147, Liverpool L69 3BS
- E** Evan Steadman Communication Group, Saffron Walden. £ 0799 22612
- I** ITP, Solihull. £ 021-705 6707
- K** Douglas Temple Studios, Bournemouth. £ 0202 20533
- M** Montbuild Exhibitions, London. 01-486 1951
- O** Online Conferences, Northwood, Middx. £ 09274 28211
- Q** Exhibitions For Industry Ltd., East Oxted, Surrey. £ 0883 34371
- T** Trident, Tavistock £ 0822 4671
- V** SDL, Dublin. £ 763871
- X** Exhibition & Conf. Services, Harrogate. £ 0423 62677
- Z** BETA Exhibitions, London. £ 01-405 6233
- A1** Institute Of Electronics, 659 Oldham Road, Rochdale, Lancs. £ 016 46PE
- L1** London World Trade Centre, Europe House. £ 01-488 2400
- V1** Jack Toothill, 76 Fircroft Road, Ipswich IP1 6PX.
- Z1** IPC Exhibitions, Sutton, Surrey. £ 01-643 8040
- A2** Hart Brown & Curtis, Piccadilly, London. £ 01-439 8556
- B2** Brintex, London. £ 01-637 2400
- S7** Madmags Ltd. £ 01-437 1002
- B8** Baroness International, London. £ 01-734 2907
- B9** British Amateur Electronics Club, Penarth. £ 0222 707813

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TRANSISTORS

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AC175	30	BC107C	12	BC175	19	BC159	14	BD201	99	BF164	30	BF853	25	MPA506	20	TP30B	40	2N708	48	2N2175	22	2N3824	60
AC126	22	BC108	10	BC175	19	BC158	13	BD202	80	BF165	50	BF854	28	MPA507	20	TP30C	40	2N710	30	2N2176	22	2N3825	60
AC127	22	BC108	10	BC175	19	BC158	13	BD203	80	BF166	50	BF855	28	MPA508	20	TP30D	40	2N711	30	2N2177	22	2N3826	60
AC128	20	BC108B	11	BC178	14	BC158	13	BD204	80	BF167	50	BF856	28	MPA509	20	TP30E	40	2N712	30	2N2178	22	2N3827	60
AC128K	37	BC108B	11	BC178	14	BC158	13	BD205	80	BF168	50	BF857	28	MPA510	20	TP30F	40	2N713	30	2N2179	22	2N3828	60
AC129	26	BC108C	12	BC178	14	BC158	13	BD206	80	BF169	50	BF858	28	MPA511	20	TP30G	40	2N714	30	2N2180	22	2N3829	60
AC141	26	BC108C	12	BC178	14	BC158	13	BD207	80	BF170	50	BF859	28	MPA512	20	TP30H	40	2N715	30	2N2181	22	2N3830	60
AC141A	26	BC108C	12	BC178	14	BC158	13	BD208	80	BF171	50	BF860	28	MPA513	20	TP30I	40	2N716	30	2N2182	22	2N3831	60
AC141B	26	BC108C	12	BC178	14	BC158	13	BD209	80	BF172	50	BF861	28	MPA514	20	TP30J	40	2N717	30	2N2183	22	2N3832	60
AC142	26	BC108C	12	BC178	14	BC158	13	BD210	80	BF173	50	BF862	28	MPA515	20	TP30K	40	2N718	30	2N2184	22	2N3833	60
AC142A	26	BC108C	12	BC178	14	BC158	13	BD211	80	BF174	50	BF863	28	MPA516	20	TP30L	40	2N719	30	2N2185	22	2N3834	60
AC142B	26	BC108C	12	BC178	14	BC158	13	BD212	80	BF175	50	BF864	28	MPA517	20	TP30M	40	2N720	30	2N2186	22	2N3835	60
AC142C	26	BC108C	12	BC178	14	BC158	13	BD213	80	BF176	50	BF865	28	MPA518	20	TP30N	40	2N721	30	2N2187	22	2N3836	60
AC142D	26	BC108C	12	BC178	14	BC158	13	BD214	80	BF177	50	BF866	28	MPA519	20	TP30O	40	2N722	30	2N2188	22	2N3837	60
AC142E	26	BC108C	12	BC178	14	BC158	13	BD215	80	BF178	50	BF867	28	MPA520	20	TP30P	40	2N723	30	2N2189	22	2N3838	60
AC142F	26	BC108C	12	BC178	14	BC158	13	BD216	80	BF179	50	BF868	28	MPA521	20	TP30Q	40	2N724	30	2N2190	22	2N3839	60
AC142G	26	BC108C	12	BC178	14	BC158	13	BD217	80	BF180	50	BF869	28	MPA522	20	TP30R	40	2N725	30	2N2191	22	2N3840	60
AC142H	26	BC108C	12	BC178	14	BC158	13	BD218	80	BF181	50	BF870	28	MPA523	20	TP30S	40	2N726	30	2N2192	22	2N3841	60
AC142I	26	BC108C	12	BC178	14	BC158	13	BD219	80	BF182	50	BF871	28	MPA524	20	TP30T	40	2N727	30	2N2193	22	2N3842	60
AC142J	26	BC108C	12	BC178	14	BC158	13	BD220	80	BF183	50	BF872	28	MPA525	20	TP30U	40	2N728	30	2N2194	22	2N3843	60
AC142K	26	BC108C	12	BC178	14	BC158	13	BD221	80	BF184	50	BF873	28	MPA526	20	TP30V	40	2N729	30	2N2195	22	2N3844	60
AC142L	26	BC108C	12	BC178	14	BC158	13	BD222	80	BF185	50	BF874	28	MPA527	20	TP30W	40	2N730	30	2N2196	22	2N3845	60
AC142M	26	BC108C	12	BC178	14	BC158	13	BD223	80	BF186	50	BF875	28	MPA528	20	TP30X	40	2N731	30	2N2197	22	2N3846	60
AC142N	26	BC108C	12	BC178	14	BC158	13	BD224	80	BF187	50	BF876	28	MPA529	20	TP30Y	40	2N732	30	2N2198	22	2N3847	60
AC142O	26	BC108C	12	BC178	14	BC158	13	BD225	80	BF188	50	BF877	28	MPA530	20	TP30Z	40	2N733	30	2N2199	22	2N3848	60
AC142P	26	BC108C	12	BC178	14	BC158	13	BD226	80	BF189	50	BF878	28	MPA531	20	TP30AA	40	2N734	30	2N2200	22	2N3849	60
AC142Q	26	BC108C	12	BC178	14	BC158	13	BD227	80	BF190	50	BF879	28	MPA532	20	TP30AB	40	2N735	30	2N2201	22	2N3850	60
AC142R	26	BC108C	12	BC178	14	BC158	13	BD228	80	BF191	50	BF880	28	MPA533	20	TP30AC	40	2N736	30	2N2202	22	2N3851	60
AC142S	26	BC108C	12	BC178	14	BC158	13	BD229	80	BF192	50	BF881	28	MPA534	20	TP30AD	40	2N737	30	2N2203	22	2N3852	60
AC142T	26	BC108C	12	BC178	14	BC158	13	BD230	80	BF193	50	BF882	28	MPA535	20	TP30AE	40	2N738	30	2N2204	22	2N3853	60
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AC142W	26	BC108C	12	BC178	14	BC158	13	BD233	80	BF196	50	BF885	28	MPA538	20	TP30AH	40	2N741	30	2N2207	22	2N3856	60
AC142X	26	BC108C	12	BC178	14	BC158	13	BD234	80	BF197	50	BF886	28	MPA539	20	TP30AI	40	2N742	30	2N2208	22	2N3857	60
AC142Y	26	BC108C	12	BC178	14	BC158	13	BD235	80	BF198	50	BF887	28	MPA540	20	TP30AJ	40	2N743	30	2N2209	22	2N3858	60
AC142Z	26	BC108C	12	BC178	14	BC158	13	BD236	80	BF199	50	BF888	28	MPA541	20	TP30AK	40	2N744	30	2N2210	22	2N3859	60
AC143	26	BC108C	12	BC178	14	BC158	13	BD237	80	BF200	50	BF889	28	MPA542	20	TP30AL	40	2N745	30	2N2211	22	2N3860	60
AC143A	26	BC108C	12	BC178	14	BC158	13	BD238	80	BF201	50	BF890	28	MPA543	20	TP30AM	40	2N746	30	2N2212	22	2N3861	60
AC143B	26	BC108C	12	BC178	14	BC158	13	BD239	80	BF202	50	BF891	28	MPA544	20	TP30AN	40	2N747	30	2N2213	22	2N3862	60
AC143C	26	BC108C	12	BC178	14	BC158	13	BD240	80	BF203	50	BF892	28	MPA545	20	TP30AO	40	2N748	30	2N2214	22	2N3863	60
AC143D	26	BC108C	12	BC178	14	BC158	13	BD241	80	BF204	50	BF893	28	MPA546	20	TP30AP	40	2N749	30	2N2215	22	2N3864	60
AC143E	26	BC108C	12	BC178	14	BC158	13	BD242	80	BF205	50	BF894	28	MPA547	20	TP30AQ	40	2N750	30	2N2216	22	2N3865	60
AC143F	26	BC108C	12	BC178	14	BC158	13	BD243	80	BF206	50	BF895	28	MPA548	20	TP30AR	40	2N751	30	2N2217	22	2N3866	60
AC143G	26	BC108C	12	BC178	14	BC158	13	BD244	80	BF207	50	BF896	28	MPA549	20	TP30AS	40	2N752	30	2N2218	22	2N3867	60
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AC143J	26	BC108C	12	BC178	14	BC158	13	BD247	80	BF210	50	BF899	28	MPA552	20	TP30AV	40	2N755	30	2N2221	22	2N3870	60
AC143K	26	BC108C	12	BC178	14	BC158	13	BD248	80	BF211	50	BF900	28	MPA553	20	TP30AW	40	2N756	30	2N2222	22	2N3871	60
AC143L	26	BC108C	12	BC178	14	BC158	13	BD249	80	BF212	50	BF901	28	MPA554	20	TP30AX	40	2N757	30	2N2223	22	2N3872	60
AC143M	26	BC108C	12	BC178	14	BC158	13	BD250	80	BF213	50	BF902	28	MPA555	20	TP30AY	40	2N758	30	2N2224	22	2N3873	60
AC143N	26	BC108C	12	BC178	14	BC158	13	BD251	80	BF214	50	BF903	28	MPA556	20	TP30AZ	40	2N759	30	2N2225	22	2N3874	60
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AC143P	26	BC108C	12	BC178	14	BC158	13	BD253	80	BF216	50	BF905	28	MPA558	20	TP30BB	40	2N761	30	2N2227	22	2N3876	60
AC143Q	26	BC108C	12	BC178	14	BC158	13	BD254	80	BF217	50	BF906	28	MPA559	20	TP30BC	40	2N762	30	2N2228	22	2N3877	60
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AC143T	26	BC108C	12	BC178	14	BC158	13	BD257	80	BF220	50	BF909	28	MPA562	20	TP30BF	40	2N765	30	2N2231	22	2N3880	60
AC143U	26	BC108C	12	BC178	14	BC158	13	BD258	80	BF221	50	BF910	28	MPA563	20	TP30BG	40	2N766	30	2N2232	22</		

INDUSTRY NOTEBOOK

By Nexus



Impotence

From the tremendous bickering over the economy, one fact has plainly emerged. The Chancellor, any chancellor for that matter, is virtually impotent. The best that can be hoped is to guide the economy. A chancellor cannot control it.

Even in a totalitarian state such as the USSR there are always factors beyond government control that push programmes off course. A disastrous harvest, for example, or people who prefer to drink vodka rather than work diligently.

In our own case the government, for social as well as political reasons, continued to pump massive additional resources into steel, shipbuilding, mining and the automotive industry. And this on top of failure to control the rest of the public sector expenditure, so that at mid-term in the Government's life it had actually increased, although for two years critics had constantly complained of cuts.

The barely concealed sniggers by opposition parties to Mrs Thatcher's surrender to the miners' demands and other financial calls from the nationalised industries, predictably turned to howls of rage when the bills came in on budget day.

The pre-budget queue of supplicants pleading their special causes was even larger this year. In the event, nobody was satisfied and there were loud cries of complete disaster. And so it is, after every budget, except that complete disaster never comes.

Of course exaggeration is part of the stock in trade of all politicians and the popular press. Fortunately, the fact that unemployment of qualified electrical and electronics engineers has almost tripled in the past year has escaped their notice. Imagine the headlines, the parliamentary questions! But don't get scared, the statement is virtually meaningless although true. The ac-

tual figures in percentage terms are an increase, according to the recent IEE Salary Survey, from 0.3 per cent to 0.8 per cent.

The same survey shows that public sector engineers are once again pulling ahead of their private sector colleagues in salary scales. The relative increases in 1980 were 27 per cent and 19 per cent respectively. At least in our profession, if not in others, public service employees are doing very nicely thank you.

Overall, the budget is not harmful to the electronics industry and in many ways is beneficial. The reduction in MLR and the decline in international value of sterling is helpful to everybody. More exciting is the encouragement of new businesses. Most of today's great entrepreneurs in the electronics industry originated in one or two people or a small team with bright ideas starting up on their own in quite a small way.

Avionics

I often think the world would be a happier place if success was accorded the same publicity as failure. Instead of deploring our inability to build commercial ships cheaper than the Japanese or Koreans, we might spend a little time rejoicing in the success of the British avionics industry whose products sell world-wide, not least to America.

Few people realise that of the total cost of a modern military aircraft as much as 50 per cent and typically 40 per cent is in electronics. The figure is not all that much lower for civil airliners. If we add in all the ground components such as radar, instrument landing systems, and communications the immensity of the market becomes apparent and it is a market in which Britain has a first-class reputation, enjoyed ever since the pioneering days of avionics 50 years ago and never relaxed since.

Marconi, Ferranti, Smiths, Plessey and Decca are all names to conjure with in this high technology activity. Racal, apart from ground communications, has been less active in this area but will no doubt become more prominent through the re-organised Racal-Decca company.

An interesting development is the Marconi entry into the aerial platform itself as well as the airborne avionics. There is no intention of course of joining the big-time airframe manufacturers. Don't expect a Marconi successor to the Tri-Star or the 747. Marconi Avionics MACHAN remotely-piloted vehicle (RPV) is far more modest having only a 12-ft wingspan and being powered by an 18hp two-stroke engine driving a ducted pusher propeller.

The machine can carry a 33lb payload for a cruising duration at 64 knots of 2 hours, with a smaller duration at faster speeds up to a maximum in level flight of 115 knots. The airframe, powerplant and flight control system has been developed at the Cranfield Institute of Technology under sub-contract.

A payload of 33lb would not have been of much value only 10 years ago. Today it's surprising what you can pack in. The microprocessor-controlled digital autopilot

is all on a single card only 6in by 4in. Seven other similar cards comprise the total electronics package including all the TV camera processing and video data links to the ground. In case you haven't guessed already, the MACHAN is a spy-in-the-sky drone for battlefield surveillance.

Incidentally, there is a touch of the old Empire in the name. MACHAN is an old Hindi word for a tree-top surveillance platform and is pronounced "Ma-shahn" with the accent on "shahn".

Leisure

The great 19th Century reformers such as Ruskin had a vision that if labourers in the factories and fields had better working conditions and especially shorter working hours, they would nobly turn to self-education and in particular devote much time to the creation of beauty and cultivation of the arts. More than a century later their hope has been achieved in respect of increased leisure time for all, but hardly in the use made of it if we are to believe, for example, that the daily attendance at Bingo sessions is six million.

Electronics, judged solely as a tool, is impartial to noble or ignoble use. I note that two recent export orders are both coupled with the human weakness of gambling. The Tote Agency in Melbourne has just upped its installation of 32-track Racal recorders to a total of 16 machines to cope with telephone bets. These expensive machines are those normally used to record all traffic information at airports. The Tote now has 464 channels of continuous recording to cope with 50,000 calls a day with exact timings to eliminate fraud.

The other order, greater in value, is for comprehensive colour TV at the Singapore Turf Club. Three Marconi cameras, video recorders and other equipment are to be used for surveillance of the races, judging by the stewards, and monitoring for the spectators. The system will also be linked by microwave to three other racecourses in Penang, Perak and Selangor. The Singapore Club is one of the oldest, founded in 1842, but is also famed as the most up-to-date in the world.

Security

Security as a business is booming as law and order becomes an increasing problem. Thorn EMI has merged into a new Security Division the formerly separate activities of fire protection and intruder detection. The Division now has annual sales of £60 million with a high content of electronics in specialised sensors. While consolidating the business at home, Thorn EMI expect to see substantial advances in overseas business.

Performance

Good bright firms prosper through good and bad times. Yes, even in vulnerable consumer electronics. Alan Sugar has pulled it off again with Amstrad turnover up 58 per cent in the last recorded half-year and, more important, profits up 51 per cent.

WIRE WRAPPING

John Lewis

LIKE all good ideas wire wrapping is simple and effective. In its basic form wire wrapping does exactly what it says. One end of a length of wire is wrapped around a terminal and the other end is wrapped round another terminal to complete the circuit. To the non believer this may seem an unreliable way of making a connection. In fact though it is a very reliable technology which is used on circuits destined for a wide variety of uses—including the very particular military sector. Its big advantage is the ease with which changes can be affected and this is a godsend to the experimenter.

The mechanics of the wire wrapped joint are that a bared wire is wrapped a number of times around a square post—typically 0.025 inches square (Fig. 1.). The actual pressure between the wire and the post can initially be as high as 100,000 lbs per sq in. though over time it may drop to 10,000 lbs per sq in. due to stretching. Even so the oxide layers are crushed or sheared and a gas tight seal is formed between the wire and the post; migration of the metals involved at the joint also takes place thus improving the electrical connection.

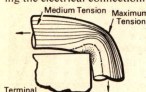


Fig. 1. The wire wrapped connection around the terminal crushes the oxide layer on both the wire and the terminal

TYPES OF WRAPS

One problem when just the bared wire was wrapped round the post was its lack of resistance to vibration (Fig. 2a.). However, by continuing the wrap to include a turn or two of the insulated portion of the wire as well this is much improved and strain relief is also provided. This type of wrap is known as a 'modified wrap' and is standard now for most applications (Fig. 2b.).

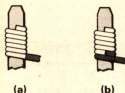


Fig. 2(a). In a standard wrap only the bare wire is wrapped around the terminal. This method is preferred with large gauge wire

Fig. 2(b). In a modified wrap the first 1 to 1 1/2 turns are made with the insulation wrapped around the terminal

TYPES OF TOOLS

So here we have an excellent idea but how can it be implemented by the amateur. The first thing that is required is a wrapping tool which can be either electrically or manually operated, secondly some 30 a.w.g. (0.25mm) wire, thirdly a wire stripper (though this can be an integral part of some wrapping tools) and

lastly a supply of suitable i.e. sockets and terminals which have square posts long enough to accommodate at least 3 wraps.

CIRCUIT BOARDS

Obviously some form of circuit board is still required and this can be the traditional 0.1 inch stripboard provided care is taken to isolate the necessary tracks. Better though are the d.i.p. boards which have the requisite copper patterns for individual i.c.'s as well as some additional contacts, isolated from the others, together with some continuous tracks possibly on the top surface of the board as well for power and bus connections.

To build a circuit one first inserts the required number and type of sockets and solders them into place. The soldering is necessary since additional posts may be needed to be inserted in the spare holes by each socket pin should more than three connections be required to any particular i.c. pin. At this stage it helps if the pin terminals are identified on the underside of the board since it is very easy to transpose say, pin 1 and 16, when 'working upside down'. A small piece of masking tape stuck between the legs of the i.c. socket with pin numbers written on it helps to prevent such errors.

HOW TO MAKE A JOINT

To make a joint about an inch of insulation is stripped from one end of the wire (Fig. 3.). (If you are using one of the wire strippers especially designed for this application or a tool which has an integral stripper the length stripped will be predetermined so there is no need to measure.) The end of the wrapping tool has two holes in it, a large one in the centre and a smaller one on

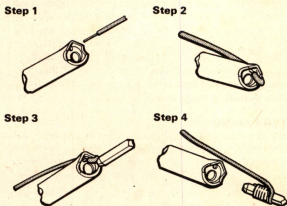
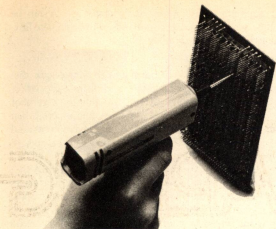


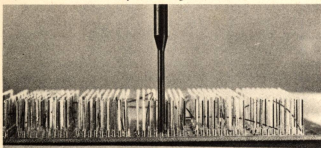
Fig. 3. Method for making a wire wrapped joint

the circumference. The bared wire is pushed into the smaller hole as far as it will go—in fact some of the insulated part will also disappear if a modified wrap is being made—and then bent at



The Hobby wrap tool from Vero Electronics has been designed specifically for the amateur market. A Ni-cad battery drives the tool and an optional plug-in charger is available. A switch on the end of the barrel enables the same bit to be used for wrapping and unwrapping

90°. The tool is then placed over the appropriate post so that it enters the larger, central hole of the tool and pushed down as far as it will go. It is then rotated clockwise until the connection is completed. If a powered tool is being used allow about 2 secs running time, if it's a manual one then it should be turned without undue pressure for approximately 10–12 turns. Take a tool off the post and the wrap is made. The turns should be laying flat and close to each other, if they are not or if they overlap then either the tool has been pulled up as it was turned or not allowed to rise as the wrap was being made.



Typical wire wrapped backplane

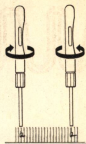
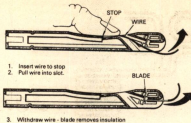
It takes longer to describe the process than to actually do it and once a few have been done you become quite adept at it. The wire is led across to the post to which the next connection is to be made and cut so that it is about 1½ times too long—the end is stripped and a wrap made in a similar fashion to that described above. And so on following the circuit diagram to make the various connections called for. Note that it is good practice to keep both ends of the wire at the same level otherwise it can be difficult to make changes.

UNWRAPPING

Should a change be required the joint is just unwrapped. In some cases a special unwrapping tool may be needed though most wrapping tools if turned anticlockwise do unwrap as well. So the tool is slipped over the post given a few turns anticlockwise and removed leaving the unwrapped joint ready to be taken off. It is false economy to try and use that joint again by straightening the wire and rewrapping, much better to replace it totally. If you suspect that changes will be needed once the circuit is made then leave sufficient slack in each connection so that additional wraps can be made.

A new development is a special tool using a wire which does

Clockwise to Wrap
Anti-clockwise to unwrap



The Combiwrap tool from Vero Electronics is a combined wire stripper, wrapping and unwrapping tool

not require stripping. The tool has a bobbin of wire attached to it feeding down through the tool into the wrapping bit. In use the tool bit is placed over the post, the free wire end is held whilst the whole tool is rotated through 8 turns and then removed. The tool, with wire trailing is moved onto the next post and the procedure repeated. To cut the wire a button on the tool is pressed and two further turns of the tool will cut the wire at the joint. What happens is that the insulation on the wire is automatically pierced and displaced by the square corners on the post thus making a good electrical, gas tight joint.

When the wrapping is finished the connections should be checked against the circuit diagram and here the advantage of using coloured wires for different parts of the circuit becomes apparent. If all seems well the i.c.'s can be inserted into their respective sockets—the right way round—and power applied. Hopefully it will work first time, if not then fault finding and rectification is easy compared with printed circuit boards.

* Illustrations by courtesy of Vero Electronics, Industrial Estate, Chandler's Ford, Hants.

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WEMON

REVIEWED

by Dr. A.A. BERK

THE WEMON monitor, produced by *Watford Electronics*, is an overall system monitor for the UK 101-Superboard family of computers. The Monitor in any machine of this kind is in constant use for such activities as interpreting keyboard data, keeping the screen formatted, allowing editing of programs, breakpoints, machine code writing etc. The revolutionary nature of WEMON is its realisation on a 2532 (4K Bytes) erasable programmable read-only memory (EPROM). These devices retail at £15-£18, normally, and WEMON costs less than £20. The reason for its requiring such a large amount of memory for all its functions lies in two or three of its advanced facilities. Firstly, full on-screen editing of BASIC programs is available—you simply move the cursor to any point on the screen containing a listing of the program, effect an insertion, change or deletion, and WEMON takes care of inserting the changes into the stored copy of your program. The second important feature is concerned with the sophisticated way in which the device controls loading and saving to tape. One of the most memory intensive parts of this function stems from the fact that WEMON's method of tape storage is fully compatible with the usual methods for 101/Superboard machines. Thus, although under WEMON it is vastly more sophisticated than normal, friends can still swap taped versions of programs with alacrity.

A third feature of some importance for the programmer, though less memory intensive than the above, is WEMON's BASIC keyword presentation facility. By this means, BASIC keywords such as FOR, POKE, etc may be called up by single keys on the keyboard. Two keystrokes are necessary, as SHIFT and CONTROL have to be pressed together first, released and followed by the key associated with the BASIC function required.

The chip containing WEMON has to be fitted into the memory space on the board, and to do this, a set of links and track cuttings must be performed on the p.c.b. before starting. These modifications are quite straightforward, and though I did not perform the modification myself, they seem to be well described in the manual.

The facilities available are described below, and have mostly been checked, during the review, on a Superboard. The chip comes in various versions, for the different machines it fits.

START UP

When the machine is switched on, the BREAK or RESET key is pressed, and a menu containing five letters appears:

M/C/W/D/U?

The machine is asking for a response from the user, and any of these letters can be typed, followed by a RETURN, to open one set of facilities available. **M** starts the machine code monitor, **C** is cold start for BASIC, **W** is warm start, **D** performs an indirect jump to a routine starting at 9800 (Hex), although this can be

changed if required, and **U** jumps to a vector which can be defined by the user. The last two commands allow complete flexibility of use from the very beginning.

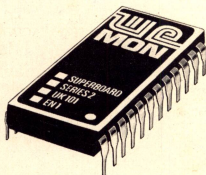
KEYBOARD

The keyboard is decoded as normal with alpha lock distinguishing between upper case teletype, and normal typewriter mode with lower case and use of SHIFT. In addition, several of the keys have special cursor control functions, and others, when used in conjunction with the CONTROL key, have command functions. See Table 1. CTRL(S) toggles between 24 and 48 characters per line with half the number of lines in the second case. CTRL (E) allows a jump to extensions to BASIC, CTRL(Q) changes to a mode whereby you can print characters on the screen corresponding to each of the cursor commands. By this means, using a PRINT statement, the cursor may be moved around the screen by your BASIC program—very useful for easy screen formatting under program control. The symbols used to signify these cursor commands are chosen to be logical—e.g., the cursor down symbol is a down arrow, etc. Table 1 also shows that cassette tape motor control is included from the keyboard to allow the tape to be rewound or forward wound without having to unplug the remote connection. CTRL(D) inserts a blank line between two BASIC lines of text to allow a new line to be written in. In addition, cursor movements are effected by LINE FEED and REPEAT, with their inverses occurring by the use of SHIFT with these keys. SHIFT RUBOUT, logically enough, produces the INSERT function in BASIC text, and SHIFT ESC (using the LEFT SHIFT) produces a screen clear.

These facilities are very useful indeed during program writing, and after a few minutes of use, it becomes very irritating to return to the old method of rewriting lines to effect changes. The only criticisms I can make are, firstly that the cursor is chosen, sensibly, to flash on and off, but the speed is rather low; and secondly, while stepping along a line, or moving up and down the screen using auto repeat, the cursor will stop flashing, and disappear. It is therefore impossible to watch the progress of the cursor on the screen to see when it has arrived at its destination.

BASIC

As mentioned above, WEMON has full screen editing, including insert both character and line. An exciting aspect of the editor is its ability to be used within a program. As explained above, characters corresponding to the editing commands may be included in PRINT statements to allow simple program formatting of the screen. By this means, a program is able to treat the screen as a "sheet of paper" around which the cursor may be moved at will to place printout easily at any position on the screen.



Another advanced feature of the monitor is its ability to extend the BASIC words which it can recognise. This is activated by CTRL(E). Before this has been performed, BASIC responds with the usual SN error if it finds a command which it does not

TABLE 1

REPEAT = Cursor Right
 DELETE = Rubout
 LINE FEED = Cursor Down
 ESC = Home Cursor

Use of SHIFT reverses these functions, e.g. SHIFT
 LINEFEED = Cursor Up., and SHIFT ESC clears the screen.

CTRL(E) = Basic Extension
 SHIFT RUBOUT (1E) = Insert
 CTRL(X) = Cursor Left
 CTRL(Z) = Cursor Up
 CTRL(S) = Video Swap
 CTRL(Q) = Toggle Quotes
 CTRL(N) = Delete
 CTRL(H) = Cursor Right
 CTRL(J) = Cursor Down
 CTRL(T) = Tape on/off
 CTRL(D) = Open Screen
 CTRL(P) = Toggle Print Flag

recognise. After CTRL(E), it performs further tests before rejecting the command. If the tests succeed, then a jump is performed to a location named EXTVEC. This is a three byte location which should contain a jump to another routine which can contain anything you wish. Some parameters are passed via the stack, and use of this function can, of course, crash the system if not set up correctly. Thus, the BASIC interpreter is no longer completely closed, any further facilities required can simply be strung on as desired.

A useful, though simple, addition to the system is use of the SPACE key to slow down a listing. Instead of flashing uncomfortably before the user's eye, a long list can be slowed down to reading speed by holding down the SPACE bar.

A printer routine is included in the monitor, but it expects a 6520 parallel I/O chip to be present at base address 8800(Hex). The command CTRL(P) toggles the print facility in and out, and every call to the normal output routine tests this flag and prints accordingly. The protocol is Centronics. Naturally, any other parallel device may be attached here if it handshakes in the Centronics manner.

The cursor symbol and flash rate are supposed to be user selectable via certain memory locations, but neither of these facilities worked on my version of the chip. I am assured that this will be rectified on the full production version, and these additions appear to be easy enough to include.

TAPE HANDLING

This is one of the areas of WEMON where it really scores very high marks. The whole problem of tape handling seems to have been cleared up by this monitor. The tape is automatically turned on and off by the program via a very simple hardware modification to the p.c.b. which includes an i.c. driver and a p.c.b. mounted relay. The RTS line of the 6850 ACIA is used to drive this facility in a very neat and easy to use manner. Once the remote connection has been plugged into the tape recorder, it does not have to be removed to rewind etc.—CTRL(T) being used from the keyboard to allow normal tape use when not required to be under program control.

Both (optional) named-files and part-SAVES are allowed. To save a file to tape, the command: SAVE"AAAAAA" is typed being followed by RETURN, opening quotes being mandatory, closing quotes are not required. The name (up to six alphanumeric characters) can be omitted (along with quotes) if no name is required for the file. At this point, a five second delay is encountered during which any tape leader is cleared, and then the message "SAVING AAAAAA" will appear followed by the command "LIST". At this point, the user may type a line-number followed by RETURN, to tell the computer where to

start the listing from. Just RETURN starts the listing from the first line. The file then lists out on the screen as usual until the process is complete, when SPACE RETURN switches off the tape and clears the SAVEFLAG—which signals the computer whether or not to output to tape when a LIST is performed.

Loading from the tape is similar, with one or two extra tricks. If the opening quotes are omitted, the first character of the name is ignored in the name comparison. If a "*" is included in the name, the name comparison stops at that point. Thus:

LOAD"HELLO

will load the same file as:

LOAD"HE*

In addition, all named files encountered during a search of the tape are listed on the screen during the process, to allow the user to keep track of what is happening.

Machine code tape files are also handled with great efficiency by WEMON. It is claimed that they transfer some three times faster than normal! These files may only be handled from the machine code monitor, which is described later. S and L are used instead of SAVE and LOAD, and no quotes are necessary for file names. The form of the SAVE operation is as follows:

S AAAAAA(RETURN) XXXX-YYYY

After the RETURN, the cursor waits for the mandatory address parameters for the SAVE routine—all code from address XXXX to the location immediately preceding YYYY is thus saved to tape under the file name of AAAAAA.

LOADING of the block of data may be made to the same locations, or a different set entirely. Leading zeros are not required in the address parameters, and once again, the file name is optional.

MACHINE CODE MONITOR

The machine code monitor has one or two useful features not found on other monitors, though WEMON is much more a BASIC handler, and the features should not be expected to be wide ranging.

After RESET, if M is pressed, the machine code monitor is entered, and one of seven single letter commands is available. Unfortunately, if any other letter is pressed instead, the machine hangs up, and RESET has to be pressed to return to normal use. Each command has a set of parameters which are associated with that command's use, and if these are miss-typed in certain ways, the machine hangs again. This fragility in the software is irritating if you type fast, as mistakes are inevitable. Each command must be used, therefore, with some care as to format.

When the machine code monitor is entered, an immediate display of the registers is shown at the top of the screen, and subsequent commands, including those performing scrolls to the screen, leave this line of registers displayed at all times. The R function can be used to modify the contents of this line for various purposes. The modifications to this line are loaded into the MPU registers when the G function is used—the location to which control is transferred by G is determined by the PC value shown at the top of screen. While R is being used, the cursor steps along on the line beneath the register fields being modified. By this means, the contents are not obscured by the cursor block. The cursor may be moved back and forth at will to modify any position on the line.

M allows any set of locations to be examined and modified byte by byte. A useful display feature has been included here, whereby consecutive locations treated in this way are listed vertically down the screen rather than being confined, as with the old monitor, to a one-line display. The vertical line scrolls when it reaches the bottom of the screen, leaving the register line intact. M can also be used to search through any designated

memory block for all occurrences of a particular byte. Each occurrence, with its address, is listed on the screen, and at the end the total number found is displayed.

V allows a formatted block of memory to be displayed—with scrolling if the block does not fit onto the screen. The scroll rate may be very conveniently slowed down, as for BASIC, by the use of SPACE.

B allows a block move of data in any direction. The start and end addresses of the block to be moved are given, along with the new start address for that block.

S and L have been described in the Tape Handling section above.

Breakpoints are implemented, for debugging, to allow either a branch out to the machine code monitor, or to an address specified by the user—again, maximum flexibility being the watchword.

Finally, the RS232C output of the machine may be used after the delay, and other cassette-priority routines, have been disabled by:

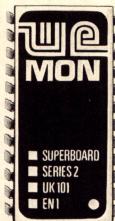
POKE\$17,255

This allows a serial system printer to be used under program control, instead of the parallel printer referred to earlier.

CONCLUSION

In addition to the above facilities, there is a very large number of subroutine entry points and functional locations included in the manual. It is fair, therefore, for the manufacturers to claim that WEMON is able to satisfy both the beginner's need for an easy to use system, and the experienced user's need for maximum flexibility and utilisation of the system offered. The version of the manual used for this review was a pre-production copy of the document, and many changes have since been incorporated; however, most of the functions are quite adequately described, and the hardware modifications well sketched.

It is inevitable that a comparison will be made between this monitor and the ever increasing number of UK101 type monitors flooding into existence. It is impressive to note that *bit for bit* this has been priced to be the cheapest monitor around; and, as it is implemented efficiently on a 4K (bytes) EPROM, it is inevitably the most sophisticated.



It was suggested that there is a user-settable location in the machine code monitor, which the machine branches to, allowing extra commands to be added, although this was not apparent in the reviewed version of the manual.

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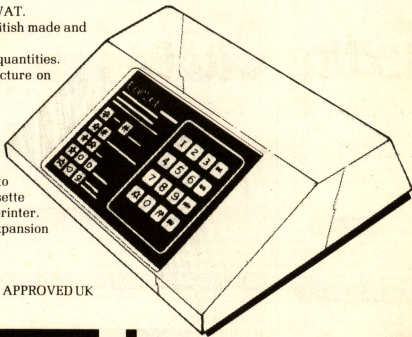
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Semiconductor UPDATE...

FEATURING CY 500 LM330

R. W. Coles

STEP THIS WAY...

Apply a voltage to an ordinary electric motor and it will immediately start to accelerate, remove the voltage and it will eventually slow down and stop. Suppose you want the motor to move through *exactly* 37 degrees and then stop dead. Impossible, unless you use gears and an electronic servo loop which monitors the position and speed of the output shaft and controls the applied voltage accordingly. Even in a full-blown servo of the sort used in proportional radio control systems, precise angular movement and positioning is difficult, and relies to a large extent on the skill of a human operator. The rate of acceleration is set more by the need to prevent "hunting" than by any other factor and is not normally controllable by the operator.

It was to overcome these sort of positioning and control problems that the "Stepper Motor" was developed, and since its introduction it has found application in a wide range of industrial systems, particularly those controlled by computers or microprocessors. The Stepper motor has several coils, commonly four, and these are switched on or off in a fixed pattern such that each change in the pattern causes the motor shaft to move through a clockwise or anti-clockwise step of a fixed angle determined by the motor design. Each coil is either switched on or switched off, so there is very little power dissipation in the driver circuitry and control of the pattern can be easily handled by a computer or a microprocessor. By rotating a pattern of ONEs and ZEROs, the controller can make the motor move through any number of precise angular steps, in any direction, at any speed and with precisely controlled acceleration and deceleration rates. All this is done *without* the need for a feedback servo loop, and with quite smooth operation at the higher rates.

If steppers are so marvellous, you may ask, why aren't they used universally? Well, for a start, you do need a computer-type controller, and it is only with the advent of the microprocessor that this has become an economical proposition. Secondly, they are becoming increasingly common in all sorts of lower cost applications. Many of the cheap printers on the market take advantage of the precise control possible with steppers and microprocessors to replace the expensive sets of cogs and levers and cams which used to do the same job.

... WITH THE CY 500

If you have a pet micro you can hook a few power transistors onto an output port, and, by writing a few machine code

routines, you can have a stepper motor obey your commands. Full control over the motor speed, direction, acceleration, and position is certainly possible by this method, but you will spend many a happy week writing the code, and when the micro is busy stepping out, it won't be able to do anything else. A new device from a firm called Cybernetic Micro Systems can make the job much easier, and it also represents an interesting new breed of "Microprocessor components", based on standard single-chip microprocessors with programmed-in software.

The CY 500 is described as a Stored Program Stepper Motor Controller, and it comes ready programmed to perform 22 special high-level stepper motor functions such as "Set rate of stepping", "Set slope of acceleration", "Declare zero reference position", "Begin Stepping", "Wait", "Execute", "Set clockwise", "Set Anti-clockwise", etc. etc. A complete program loop using up to 18 of these commands can be loaded into the CY 500 for automatic execution, or instructions can be passed and executed one at a time. Any serious application would probably use the CY 500 as a peripheral device to assist an existing microprocessor, but for evaluation and learning purposes the CY 500 can be connected directly to a parallel ASC11 keyboard, and commands entered using single letters followed in some cases by numerical parameters. Once a command letter sequence has been entered, typing the D command will cause immediate execution.

Various control inputs and outputs are available on the CY 500 chip in addition to the 4 motor "phase" lines and the 8 bit data bus, making the CY 500 adaptable to just about any application imaginable. If only a small stepper motor is to be controlled, a single additional chip such as the Sprague ULN 2823A high voltage driver array can be used as the motor interface. Larger motors will need power transistors to handle the high current pulses. The CY 500 comes in a 40 pin package and runs from a 5 volt supply. It is available in the UK from: Data Plus Ltd., Cheltenham.

POWER MISER

Have you ever needed a 5 volt supply, for MOS or TTL circuitry perhaps, which had to be derived from batteries? If power consumption and battery size have to be minimised, this apparently simple requirement can turn out to be quite a headache!

The first thing you consider is using a 6 volt supply and a regulator—then you discover that 5 volt regulators need an input voltage of around 7.5 volts for correct operation, so you increase the battery

voltage to suit. Then you realise that you will have to waste 50 per cent more power than you actually need for the logic, just to heat up a silly regulator—there must be a better way! Next, in a moment of bravado, you decide that the high efficiency of a switching regulator is what you need, only to discard this idea when you realise that it will mean going into the coil-winding business and some rather hairy design calculations, too! At this point, if you are like me, you either give in and chance running the logic at 6 volts straight from the battery (very naughty!) or you put up with the extra consumption and use an LM309 running from 7.5 or even 9 volts.

You may be pleased to know that in future you will have another, much more satisfactory, option in the form of a new voltage regulator from National Semiconductor, the LM330.

You see, the problem with the *existing* voltage regulator devices, is that they all rely on NPN transistors to do the regulating, and that means the series-pass transistor operates as an emitter follower, often a compound emitter follower, and that in turn means that the voltage at the base of the series pass element has to be well above the output voltage due to base-emitter drops. Add a bit more for the current sources used as load resistors, and you don't get much change out of 7.5 volts, especially when the regulator is cold.

Now i.c. designers are not just *perverse* in sticking doggedly to NPN emitter followers when a PNP common emitter configuration could solve the problem better, the fact is that PNP transistors are very difficult to fabricate on an i.c., and so this option has not really been available.

The LM330 is different because National have solved the problem of fabricating efficient PNP transistors on integrated circuits by using deeper diffusions to produce the so-called deep-base PNP. Using the deep-base approach National get the drop-out voltage on this 5 volt regulator down from about 2.5 volts for the NPN types to just *half a volt* for the LM330. So you can use a 6 volt battery and its terminal voltage can drop to less than 5.5 volts before the LM330 gives up! Some sacrifices have been made, because the full rated current specification is only 150 mA, a lot less than the NPN types but usually sufficient for battery applications. Protection is built in against thermal overload, reverse battery connection, input voltage transients, and even mirror image insertion of the package.

The LM330 lives in a TO 220 plastic power package, and it should be quite inexpensive when it arrives on suppliers' shelves within the next few months.



FRANK W. HYDE

COMMUNICATION CONGESTION

Commercial communication may be seriously threatened within the next decade because of lack of bands of frequencies required for domestic video and voice data slots. The two bands allowed for these purposes are the C band (6/4GHz) and the K_a band (14/12GHz). In the C band at the beginning of the year two slots only were left. At that time the FCC (Federal Communications Commission) of the USA had authorised 20 more launches, in addition to the nine in operation, between 50deg. W long. and 150deg. W long. This will exhaust the C band slots for geosynchronous orbits. On this basis there would be no further parts of the band available by the 1990's.

The National Aeronautics and Space Administration (NASA) have put forward a possible solution, though this is a long term matter. Nasa suggests that the K_a band (30/20 GHz) should be developed, using commercial satellites. They are preparing a demonstration of the system using several ground stations and with a spacecraft to be launched on the shuttle about 1987. If this is successful it will be possible to make use of the narrower band width and would allow the spacecraft to fly closer together without mutual interference. To this end experimental work is already under way to alleviate the problems by the study of multibeam antennas.

The multibeam antenna allows a number of spot frequencies in narrow beams to be used without interference. On-board switching would enable the spot beams to be interconnected so that signals could be switched from downlink to uplink in any combination. This technique is not new of course except at the frequencies proposed. High power transmitters would be used in the satellites at the frequencies considered together with low noise on-board receivers. Owing to the effect of rain which restricts operation on the K_a band, the links between ground stations would be by microwave and/or fibre optics.

The K_u band is fully available and it is expected that there will be sufficient slots available. It has of course the advantage that the aerials can be mounted on normal buildings in crowded areas. However, the possibility of fading due to rain would still be present. Nevertheless this is an important step in combating the band difficulties. A number of companies are engaged actively in the production of satellites and equipment undaunted by the difficulties.

ACTIVITIES OF THE USSR

During 1980 the Soviet Union launched more manned missions than in any year of their space history. The six-manned flights of 1980 also included the longest operation of astronauts so far in space. Their record will no doubt soon be surpassed by themselves. It confirms that the Russians continue to be set now on the path of space station operation. They have in fact now achieved more than double the manhours of the USA spent in space. In addition to the manned missions, automatic tankers to refuel and restock the Salyut-6 were operated. There were fewer missions in 1980 devoted to scientific activities, in favour of military projects.

In 1979, 74 military missions were known to have operated. In 1980, no less than 85 spacecraft were launched. It is understood that they continued the policy of flying two man crews for six month shifts with the addition of short period additions of crews from other parts of the world and satellite countries of the Soviet Union. There is also the possibility of guest astronauts from France participating in missions.

Salyut-6 is to be replaced by Salyut-7. This was originally planned for 1980 but the serviceability justified continued use and indeed there may be some manned activity this year. The new three man Soyus-T transport will add considerably to the versatility of these vehicles. The Russians also plan to send scientists and engineers to do active experimental work and to be free of piloting duties.

Another development is that they have demonstrated their ability to operate Soyus-T spacecraft in a way that allows the orbital modules to be left before re-entry takes place. This presents the possibility of leaving the orbital module docked with the space stations. This would necessitate the provision of more docking points. It is readily appreciated when looking at the models in the permanent space exhibition in Moscow that it is possible to extend space stations both vertically and horizontally like a Leggo construction kit.

The large antenna that was deployed in 1980 paves the way for space building and it can easily be seen that with little additional skill, the possibility of large platforms such as the proposed Satellite Power System, measured in kilometres in extent, is within the immediate future. With their development of large boosters and their already active work with a re-entry winged vehicle, they could have a space station to support ten or more crewmen on a permanent basis. All this opens up new vistas for the USSR. No doubt there will be military advantages and the new booster will enable geostationary activity to be advanced.

The lag behind missions are given here as

known in late March 1981. For example, the GAIS military communications satellites, a group of four vehicles, the first of which should have been launched in 1979. The four positions planned are at 25deg. W long., 85deg. E long., 45deg. E long., and 170deg. W long. The frequency allocated for these satellites is in the 8-7GHz band. A mission that has been delayed also is the Viona communications system. These satellites consist of a group of 7 units and would provide a service similar to that of Marisat.

There seems to be a possibility of delay on another new system called Louch. It is believed that this consists of spacecraft positioned round the world to compete with the Intelsat 5 system. The frequencies of operation are said to be 11GHz downlink and 14GHz uplink. Six Molniya craft were launched during 1980 but it seems that two at least are failures. A number of other missions were flown during 1980 and many are presumably vehicles that play a dual role—that of part research with alternative military use. During 1980 all but one of the spacecraft were launched from Plesetsk.

Most projects in 1980 were increased in number compared with the same types launched in 1979. It is possible to see the pattern of the Soviet thinking by a study of the disciplines involved.

THE HALLEY COMET MISSIONS

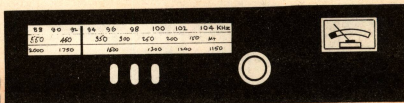
Three separate missions are to be attempted by the European Space Agency, the USSR and Japan, for a comet encounter. A meeting has been arranged to set up the necessary requirements for the pooling of the data obtained. The present plans for the encounter would mean that the Soviet comet probe would arrive shortly before the ESA spacecraft, the Giotto. Pictures taken by the Soviet vehicle could be useful for correcting the Giotto to best position perhaps even closer than the planned target distance of 1,000km. Russia has revised the strategy for the Venera unmanned mission to Venus by including a probe to be released from the Venera in mid 1985 to an encounter of the comet within a distance of 10,000 to 50,000km. Japan's project is designated "A" with no other details available at the moment.

THE SOLAR POLAR MISSION

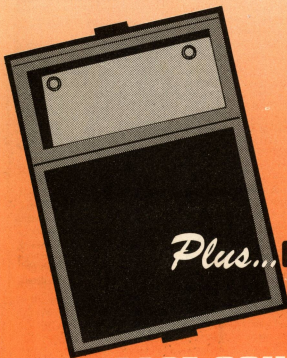
As was forecast in the last issue of *Spacewatch* there has been sharp reaction to the cut-back of programmes by the United States affecting the NASA cooperative mission with ESA. The Director General of ESA, Erik Quistgaard, has urged each member State to make the approach of protest at ambassadorial level in the first instance. The NASA/ESA memorandum of understanding covering the cooperative activities which included return flyby Jupiter secondary missions were regarded as essential. Since the agreement was signed in March 1979, a number of alterations have been made from the US side including delays because of shuttle troubles. Rather bitterly a European official said "... we did not expect these things to happen because of the cancelling of funding and not in this way. ... it seems that the US do not realise the importance of honouring international commitments".

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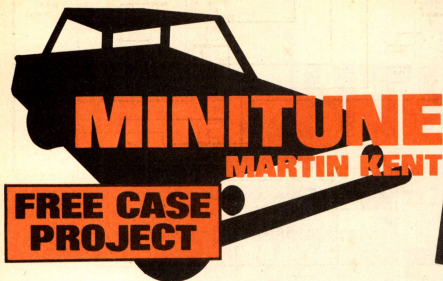
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DP400 Minitune for r.p.m., dwell, voltage and resistance testing

THE DP400 Minitune is a versatile car tester incorporating voltage, resistance, r.p.m. and dwell angle measurement ranges. Using the LE DPM200 panel meter and the special instrument case, an accurate and highly compact instrument may be easily constructed using a few additional components. The specifications listed below make the Minitune extremely useful for fault-finding in automotive electronics and for tuning an engine for better efficiency and reduced fuel consumption.

CIRCUIT DESCRIPTION

The PE Microtune featured in the December 1980 issue has proven to be a very popular instrument for laboratory or automotive use and response from readers has indicated an additional need for a compact automotive-dedicated tester which may be kept in the toolbox. The recent sharp increase in the cost of petrol emphasises again the need for correct car maintenance if fuel costs are to be minimised.

The circuit diagram of the Minitune is shown in Fig. 1 where ME1 forms the 200mV full-scale meter.

Function switching is provided by S1 and range switching by S2. The voltage ranges are provided by switched outputs from the attenuator formed by R1-R4 which are metal film types for good stability. Voltage-dependant resistor R21 is included to suppress any transients appearing at the terminals by rapid clamping to low resistance.

For resistance measurement, the ratiometric method is used such that the resistance to be measured is displayed as a ratio of an internal reference resistor, providing direct display without the need for any calibration adjustment. Thermistor TH1 and transistor TR2 are included to protect the panel meter from the accidental application of high voltage to the input terminals, when measuring resistance or checking continuity. The resistance of the positive-temperature-coefficient thermistor will rapidly increase when TR1 turns on and shunts current through the thermistor, so reducing the input current to a safe value.

In order to minimise current consumption of the instrument, the r.p.m. measurement circuit incorporates a CMOS timer, IC1, configured as a monostable. The Common Pin of ME1 is established at typically 2-8V below supply positive, enabling the CMOS timer to operate using Common and supply positive as the supply connections as it will operate

SPECIFICATION

Function	F.S.D.	Resolution	Accuracy
Voltage (d.c.)	20V	10mV	0.5% ± 1 digit
	200V	100mV	0.5% ± 1 digit
Resistance	200Ω	100mΩ	0.5% ± 1 digit
	20kΩ	10Ω	0.5% ± 1 digit
R.P.M.	20,000 r.p.m.	10 r.p.m.	1% ± 3 digits
Dwell	90°	0.1°	2% ± 3 digits

on supplies as low as 2V with consumption of 80μA. When a negative going pulse appears on pin 2 of IC1 a positive going pulse appears at pin 3, with duration 0.69 R14 C1. The output pulses are smoothed to a d.c. voltage by R9, R10, C5 and since the pulses are of constant duration this voltage is proportional to the input pulse rate.

The r.p.m. circuit is triggered by connecting Input LO to vehicle chassis and Input HI to the ignition coil L.T. trigger point.

For a four-stroke engine, the distributor shaft rotates at half the speed of the crankshaft and it can be shown that r.p.m. is related to the contactbreaker pulse rate by the equation:

$$\text{r.p.m.} = \frac{\text{pulse/min.} \times 2}{\text{Number of cylinders}}$$

Engine r.p.m. is therefore proportional to the pulse rate appearing at the L.T. trigger point, and accordingly the d.c. output from IC1 which is calibrated accordingly.

Pulse shaping and clamping circuitry is added to protect the CMOS input of IC1 from transients produced by the ignition coil inductance.

DWELL MEASUREMENTS

To simplify use of the Minitune, dwell measurements are made using the same connections to the vehicle as required for r.p.m. measurements. Dwell angle of a distributor is the angle through which the contact breaker cam rotates whilst the points are closed. To ensure correct combustion the dwell angle adjustment is very important and may be measured by comparing the points open time to points closed time or duty cycle.

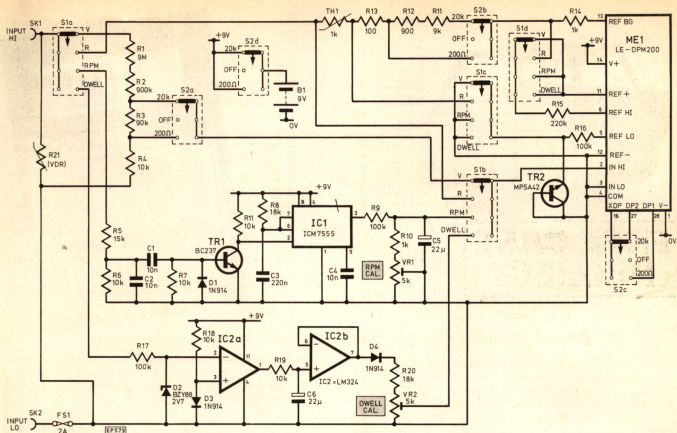


Fig. 1. Circuit of Minitune

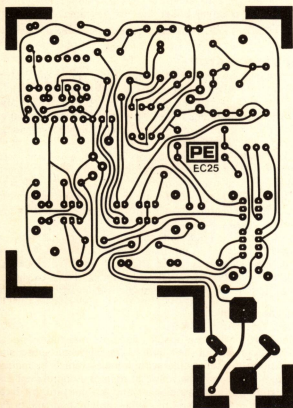


Fig. 2. Printed circuit board

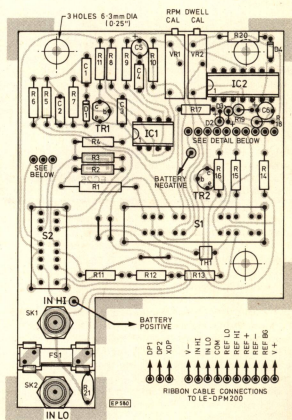


Fig. 3. Component overlay

COMPONENTS

Resistors—

R1	9M	} Metal film 0.25%
R2	900k	
R4	10k	
R5	100k	
R6	10k	} Carbon film 5%
R7	10k	
R8	18k	
R9	100k	
R10	1k	} Metal film 0.25%
R11	9k	
R12	900	
R13	100	
R14	1k	} Carbon film 5%
R15	220k	
R16	100k	
R17	100k	
R18	10k	} Carbon film 5%
R19	10k	
R20	18k	
R21	400V	

Variable Resistors

VR1	5k preset
VR2	5k preset

Semiconductors

D1	1N914
D2	BZY88 2V7
D3	1N914
D4	1N914
TR1-TR2	MPSA42
IC1	ICM7555 (CMOS)
IC2	LM324

Miscellaneous

S1 4 pole 4 position slide switch.
 S2 3 pole 3 position slide switch.
 TH1 1k PTC thermistor.
 ME1 LE DPM 200 panel meter module.
 Case.
 P.c.b.
 4 mm p.c.b. mounting terminals (2 off).
 Ribbon cable.
 Self M3 screws.
 PP3 battery and connectors.
 A kit of components (excluding the DPM200 and case) is available at £14.95 (inc. VAT and p&p) from **Lascar Electronics Ltd., Unit 1, Thomasin Road, Basildon, Essex SS13 1LH.**

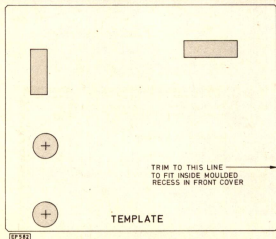


Fig. 4. Front panel template

A four cylinder engine has four distributor cam lobes spaced 90° apart which represents the maximum possible dwell angle. In practice the dwell angle is usually slightly less than two thirds the cam lobe angle.

$$\text{Dwell angle} = \text{cam lobe angle} \times \frac{100\% - \text{Duty Cycle}}{100\%}$$

The first stage of IC2 acts as a comparator with preset triggering threshold. The pulse output of IC2a is an inversion of the input pulses such that the points closed time is active "high". The pulses are averaged to produce a d.c. voltage proportional to dwell angle for input to the panel meter.

CONSTRUCTION

Construction of the Minitune is very straightforward and the component layout is shown in Fig. 2. Resistors and capacitors should be soldered in place first followed by the semiconductors and taking particular care with CMOS IC1.

Switches should be pushed down onto the p.c.b. as far as possible and checked for perpendicular positioning before soldering in place. The fuse clips and terminals should now be soldered in place.

Ribbon cable connects the panel meter to the p.c.b. and the battery connector should then be soldered in place.

TESTING AND CALIBRATION

With the instrument switched to the 20V range the display should read 0.00 and voltage measurements should not require calibration if the correct attenuator resistors have been used.

When switched to resistance ranges and the inputs open circuit the display should indicate a 1 in the leading digit with the other digits blanked which is the over-range indication. When the input terminals are shorted together, the display should read zero except on the 200 ohm range where there will be a small offset due to the fuse and switch resistance.

PULSE GENERATOR

The r.p.m. section may be calibrated using a pulse generator. Referring to the earlier equation it will be evident that a 50Hz input pulse rate corresponds to 1500 r.p.m. A low secondary output mains transformer may be used by rectifying and clipping the output. With 50Hz input VR1 should be adjusted until the panel meter reads 1.50.

To calibrate the dwell section a pulse generator with variable mark/space ratio is preferable but a 50Hz square wave source is a useful substitute. VR2 should be adjusted until the display reads 45.0 with an equal mark/space ratio input. With the input open-circuit the display should be approximately 90.0.

The Minitune is now ready for use and the p.c.b. may be screwed in place, then the panel meter located in the case and the case clipped together. The dwell and r.p.m. readings should be multiplied by two-thirds when used on six-cylinder engines and by half when used on eight-cylinder engines.

USING THE MINITUNE

The DP400 Minitune enables accurate measurements to be carried out and can be used to set the idling speed and dwell angle in accordance with manufacturers' specifications. In addition, a wide range of tests may be carried out including points, coil, air cleaner and air/fuel ratio mixture. Reference should be made to a workshop manual and/or PE January 1981 issue.

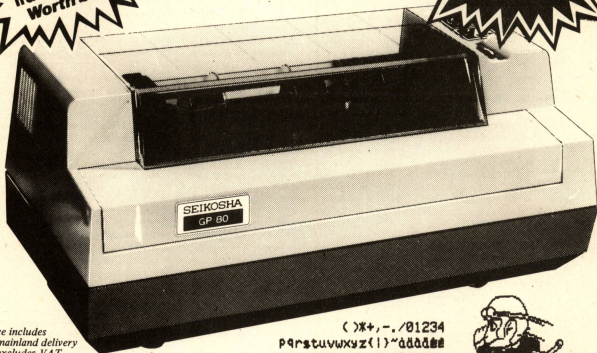
Note: the interior cutting details of the case are identical to that shown in the continuity meter article.

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Strictly Instrumental

by K. Lenton-Smith

TAKE a successful business man with a passion for something quite outside his field, add some experts to develop the ideas and you have the start of something destined to prove interesting.

Frederick C. Lowrey, who died in 1955 aged 85, firmly believed that music was a 'purifying and uplifting force' and set himself the task of developing an electric instrument capable of reproducing the pipe organ as closely as possible. Although he never played the organ, he knew organ music and became thoroughly familiar with the technicalities of the instrument itself. Once he had set himself on this course there was no turning back and he never regretted the time and money spent on the process.

At the age of 16 he started up in business, selling pots and pans from a horse-drawn 'shop' and in 1894 founded Central Commercial Investment.

In the early years of this century, Lowrey had seen the Cahill organ installed in the Telharmonic Hall, New York City. The Eastern Cahill Telharmonic Company made arrangements with the telephone company to meter music to subscribers. Mark Twain was one of the first to have his home wired for organ music by telephone. The musical notes were produced by a series of alternators and, as there was no known means of electrical amplification at that time, a handset was the only method of hearing them. Unfortunately for that company, Henry P. Morgan (a leading industrialist of that era) had difficulty placing an important business call and such was his influence that he put a stop to music by telephone.

The next electrical instrument presented to the American Public was the Choralcello, originally made in Boston, Mass. In 1918, Frederick Lowrey took over its manufacture and moved the factory to Chicago. This instrument derived its tones from piano strings which were vibrated mechanically and had either one or two seven octave keyboards. Lowrey's next essay was the purchase of an organ from a Californian inventor: he had the instrument delivered by boxcar and set up in an abandoned theatre in Chicago. This organ had vertical, resonator pipes with diaphragms near their bases which were made to vibrate at given frequencies. Though smaller than a pipe organ, it proved to be too large for a home or small chapel.

During the 1930s, Lowrey continued his quest, buying patents and employing inventors, engineers and musicians. His team at

Central Commercial experimented with generators of every known type — rotary magnetic, rotary electrostatic, gas discharge tubes and valves — during this decade. Their final choice was valve generators because no moving parts were involved and rich waveforms were available.

ORGANO

For the duration of the second world war, U.S. Government controls forbade the manufacture of musical instruments and purchase of electrical materials that were not essential to the war effort. Even so, Lowrey's first successful venture was the *Organo*, conceived by his associate Mr. Koehl and demonstrated at the 1941 Music Merchants Trade Show in New York by the fabulous Ethel Smith.

The Lowrey Organ Division of Central Commercial produced this instrument, which added the facilities of a single manual organ to an ordinary piano. The electronics—speaker, amplifier and generators—were housed in a single cabinet alongside the piano, an interconnecting cable carrying signals from switches under the piano keys. It was a divider organ with twelve LC master oscillators based on 12AX7 valves, each with its string of four 12AU7 bistable divider stages. The keyboard could be 'split' and vibrato applied overall. A simple tone forming system allowed the player to choose combinations of Principal, Horn and String at several volume levels.

Lowrey Organs were now well under way. Their first spinet model, the *Berkshire* was produced in 1954 and its voicing principles are still used in current models. In the following year, Frederick Lowrey died and, as the organ operation was foreign to its businesses, Central Commercial sold Lowrey Organs to the Chicago Musical Instrument Company.

Lowrey's new owners continued with the same vigour shown by the pioneer himself. 1956 saw the first spinet organ with sustain, chimes and glide—the *Lincolnwood de Luxe*. The *Holiday* and *Heritage* series of organs were initiated and in 1962 the company was first in the field with AOC. This feature—Automatic Organ Computer—will add full chords to a single note melody, according to left hand harmony. Runs of chords otherwise impossible to finger make it still a popular feature today.

In the 1960s, with Lowrey team were

first in producing instruments with built-in Leslie speakers and chorus reverberation. In 1965, with the advent of more reliable silicon devices, valves were replaced by transistors. In the last decade, Golden Harp (automatic arpeggio), String and Brass Symphonizers were fitted to Lowrey models and the company was collaborating with i.c. manufacturers in designing Top Octave Synthesizers and other LSI devices.

MX1

Frederick Lowrey's dream of providing the public with convincing sounding organs would have made him proud of 1981 models, though they offer far more than organ tones. At the top of the range is the MX1, which Lowrey say almost defies description, but I will have to try just the same! This is a one man band with total realism—by means of a perfect marriage between microprocessor/computer and orchestral voicing.

'Orchestration Plus' is a feature offering the choice of twelve pre-programmed, fully orchestrated backgrounds against which to play the solo on an almost unlimited number of upper keyboard registrations. The orchestrations are Big Band, Contempo, Polka, Country, Jazz Guitar, Rock, Blue Grass, Baroque, Rhythm Guitar, Disco, Waltz and Latin. Variations can be applied: for example, Big Band is programmed to play trumpets, trombones and string bass, but saxophones can take over. The fidelity of the instrument sections is such that nothing short of the highest praise is due to Lowrey's engineers.

Eighteen digital stereo rhythm patterns are available and there are three synthesizers. The Orchestral Symphonizer is polyphonic with brass, reeds and percussive tones, all of which may be coupled down to the lower manual. The Solo Symphonizer is monophonic but can be used with other polyphonic voices, whilst the Custom Symphonizer allows the player to set up his own voicing by means of envelope and filter controls.

Orchestral Percussion provides not only the usual second and third harmonic effects but also chimes and vibraphone among its nine effects. Golden Harp arpeggiates over three octaves and may be used in conjunction with Orchestral Percussion. A string synthesiser processes cello, viola and violin and the mixture can be channelled through Stereophase Chorus Celeste for a Mantovani effect.

AOC is present and, in addition to the many tab controlled voices on each manual, Custom Flute presets allow these tones to be mixed by sliders in drawbar fashion. (It is interesting to note that Lowrey have their form of Hammond drawbar, while Hammond have their version of AOC, called 'Pro Chord') Magic Genie chords are fitted with the beginner in mind.

Lowrey's claim that this is the 'ultimate organ' is certainly justified at present—and it would be good to be able to write the cheque for just under £14,000 to buy it. With technology advancing rapidly, one wonders what the back room boys will come up with next!

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NEXT to temperature measurement, pH measurement is one of the most widely used in many areas of science. pH is a measure of the concentration of hydrogen ions in a solution and is effectively a measure of acidity. Absolute measurement of pH and the monitoring of its rate of change is important in chemistry experiments but pH measurement is also of importance to the food and drink industries, to aquarists to prolong the life of tropical fish and to gardeners who use lime to control soil acidity and improve plant growth.

The DP300 pH meter provides accurate measurement of pH values in the range 0 to 14pH with resolution of 0.01pH.

MEASUREMENT OF pH

The value of pH is defined as:

$$pH = \log \frac{1}{[H^+]}$$

where $[H^+]$ is the hydrogen ion concentration in the solution.

Pure water at ordinary temperatures dissociates slightly into hydrogen ions and hydroxyl ions $[H_2O \rightleftharpoons H^+ + OH^-]$, the concentration of each type of ion being 10^{-7} gram-molecules per litre, the pH value of pure water will be:

$$\log \frac{1}{10^{-7}} = 7$$

This figure is therefore taken to represent neutrality on the pH scale.

If acid is added to water its hydrogen ion concentration will increase and its pH value will therefore decrease. Acidity is indicated by pH values below 7, and alkalinity is indicated by values above 7.

Acid has the effect of liberating hydrogen ions in solution and one of the traditional tests for acidity is to use litmus

paper. Generally acid reacts with litmus paper to turn it red, whereas alkali turns litmus blue. For accurate measurement of pH electronic methods are universally used. A simple pH probe consists of two electrodes between which a potential difference is generated when they are immersed in the solution under test. Probes are constructed on the principle of a galvanic cell with output proportional to pH value. The output is very small and a certain amount of care is required in its measurement.

CIRCUIT DESCRIPTION

The DP300 pH meter has been designed to operate with a laboratory grade probe which will be made available to PE readers. The circuit of the instrument is shown in Fig. 1 and requires few components in addition to the LE-DPM 200 panel meter.

The pH probe is fitted with coaxial cable, to protect the electrode potential difference from r.f. pickup, and connects to the instrument via plug and socket.

Operational amplifier IC1 forms a unity-gain voltage follower which presents very high impedance of typically 10^{12} at its non-inverting input to produce negligible loading of the electrode.

Amplification is provided by VR3 and a reference voltage is adjusted by VR4 such that with zero input from the electrode a reading of 7.00 is obtained on the panel meter.

CONSTRUCTION

The p.c.b. track layout is shown in Fig. 2 and it should be noted that the p.c.b. supplied from Lascar Electronics is coated to prevent ingress of moisture which could affect accuracy.

The component layout is shown in Fig. 3 and the assembly is straightforward. Link LKA should be omitted at

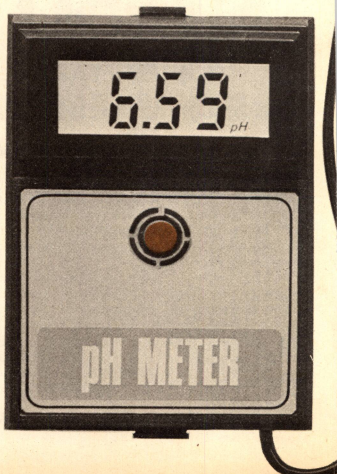
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pH METER

THE DP300 DIGITAL PRECISION
pH METER HAS A MEASUREMENT
RANGE OF 0-14 pH ± 0.01 pH

MARTIN KENT

* Please note the Front Cover and this photograph show the prototype pH meter.



is stage to ease the calibration. When all components have been soldered in place, the panel meter may be connected to the p.c.b. by the ribbon cable.

To ease the calibration of the pH meter it may be found worthwhile fixing the p.c.b. to the lower half of the case using the self-tapping screws.

ALIBRATION AND TESTING

The LE-DPM 200 is supplied tested and calibrated with 20mV, full scale and is used as a separate piece of test equipment when calibrating the pH meter to avoid the need for additional instruments.

When the p.c.b. assembly is complete, a battery should be connected to the unit and a piece of insulated wire approximately six inches long connected to the panel meter side of the LKA position on the p.c.b. The flying lead arrangement

enables voltages around the p.c.b. to be monitored on the panel meter.

When the test lead is connected to the Input LO side of the coaxial socket the display should read 0.00.

Connect a shorting link to the coaxial inputs and connect the test lead to test point A. VR1 should be adjusted to zero the offset voltage produced by IC1. Now connect the test lead to test point B and zero the offset voltage of IC2.

Now connect the test lead to test point C and adjust VR4 to provide a reading of 7.00 on the panel meter.

Remove the test lead, insert link LKA on the p.c.b., remove input shorting link and connect the pH probe to the coaxial socket.

The probe is supplied with two calibration buffer powders of pH4 and pH7. The probe should be placed in buffer pH7

COMPONENTS . . .

Resistors

R1, R2	10k (2 off) carbon film 5%
R3	33k carbon film 5%
R4, R5	100k (2 off) carbon film 5%
R6, R7	39k (2 off) carbon film 5%
VR1	100k cermet multiturn preset
VR2, VR3, VR4	22k (3 off) cermet multiturn preset

Semiconductors

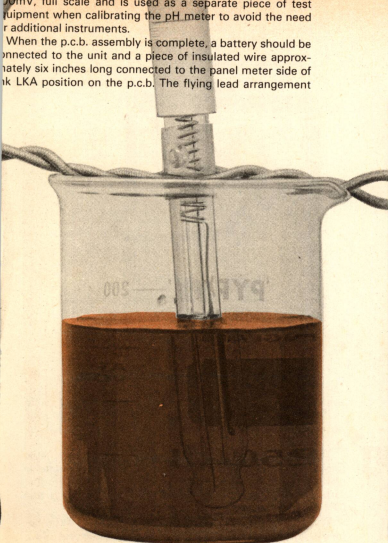
IC1, IC2, TL061CP (2 off)

Miscellaneous

ME1 Panel Meter LE-DPM 200 (See Special Offer)
Case
PP3 battery and connector
P.c.b.
Ribbon cable
Coaxial socket SK1
P.c.b. mounting switch
M3 self-tapping screws (4 off)

Constructor's Note

A laboratory grade pH probe with full operating instructions and pH4 and pH7 calibration powders is available at £22 (inc VAT) and a kit of components (excluding DPM 200 and Case) is available at £8.95 (inc VAT and p&p) from **Lascar Electronics Ltd, Unit 1, Thomasin Road, Basildon, Essex.**



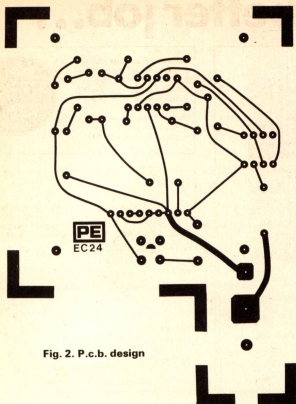


Fig. 2. P.c.b. design

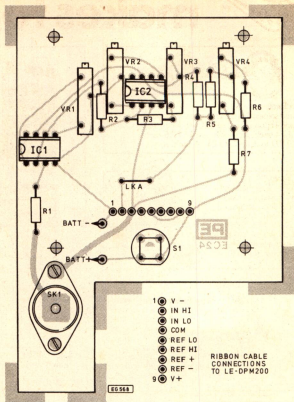


Fig. 3. Component layout

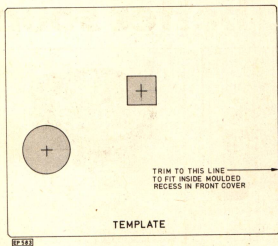
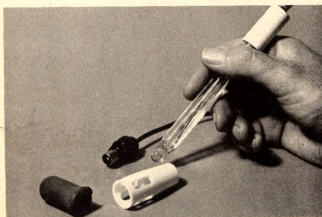
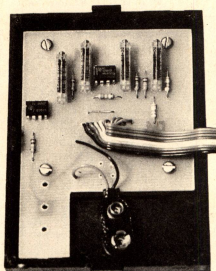


Fig. 4. Front panel template



Probe assembly



Internal view of the pH meter

solution and VR1 adjusted so that the panel meter reads 7.00. Rinse the probe in water and place it in buffer pH4 solution, adjust VR3 for a reading of 4.00. The front panel should then be drilled using the template shown in Fig. 4.

The instrument is now fully calibrated and the panel meter may be located in the top half of the case. The pH meter is ready for use for the measurement of other solutions at the same temperature and forms an ideal companion to the DP100 Thermometer.

★ The author gratefully acknowledges the assistance given by Barry James of the Aqua Chemical Co., Dover.



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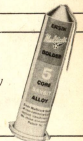
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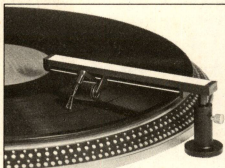


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Readout...

A selection from our Postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.
Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Rabbit, rabbit . . .

Sir—I simply had to put pen to paper in your defence. I feel that Mr. Bleck's criticism levelled at such a good mature-minded magazine just cannot be tolerated.

What I would like to know is: has Mr. Bleck checked all his electrical equipment for r.f. interference radiation, including his car, drill, washing machine, etc. After all, as Mr. Bleck doesn't like interference, why should his neighbours?

Mr. Bleck claims to have read so much about CB, and yet he knows so little about it. He says: "Every ten years or so it will become involved in some small way with a murder hunt . . ." Your magazine, plus all the informed readers will know just how many lives have been saved, and how many people have been helped by illegal CB already. Mr. Bleck also says that 99 per cent of the population is similarly disinterested. Just how naive can any person be? They say that ignorance is bliss—in Mr. Bleck's case, it is pitiful.

I have read and enjoyed your magazine for about 20 years, and have found it to be a very respectable magazine, which keeps its readers happy and informed. If Mr. Bleck had his way, it would no doubt be run on communist lines—i.e. if the Editor doesn't like it, it won't get printed.

I will go on reading your wonderful magazine even if you say things I don't agree with. Thankyou for letting me air my views, which I'm sure are shared by many other people.

R. S. Spencer,
Forest Hill.

Sir—I write in reply to Mr. Peter Bleck's letter printed in your April edition of Readout.

May I say that if "99 per cent of the population" are disinterested in Citizens Band Radio, as he so inaccurately claims, are the authorities that be (i.e. HM Government) bowing to the wishes of a one per cent minority? I doubt it.

Perhaps he should contact his local post office to help him locate the source of interference on his domestic equipment.

I would be obliged if you would print his full address, so that anyone who is interested in CB can send him a postcard to give him an idea of the support CB has. Nobody is asking him to like CB (I don't agree with foxhunting, for example)—but just to keep his childish outbursts to himself.

Ben Spencer,
Waddington.

Wonderful response

Sir—I am writing to let you know what a wonderful response I've had from an advertisement I placed in your magazine. I have been looking and hoping for a very long time that I could find someone who could build me a transistorised horn for use with my various model boats. Up until now, my search has been in vain.

Recently, I was advised to advertise in your magazine, and I'm very glad that I did—now three professional people are helping me with what I have been seeking to install in my boats.

Thankyou very much for your help and the wonderful medium that *Practical Electronics* has proved to be.

B. Clarke,
Eastbourne.

OSCILLOSCOPES

How to use them - How they work · by Ian Hickman

Oscilloscopes are essential tools for checking circuit operation and diagnosing faults, and an enormous range of models is available. But which is the right scope for a particular application? Which features are essential, which not so important? What techniques will get the best out of the instrument?

Ian Hickman, experienced in both professional and hobbyist electronics, has written this book to help all oscilloscope users - and potential users. After introducing basic principles for readers new to the subject, he explains in detail the features of typical simple and advanced real-time oscilloscopes, plus accessories such as probes and cameras. He advises on how to choose and operate scopes, and how to avoid common pitfalls; he also describes special-purpose instruments, from small portable scopes to storage scopes and spectrum and logic analysers. Finally, to give readers a better understanding of how oscilloscopes work, he explains the principles of the cathode-ray tube and basic scope circuitry.

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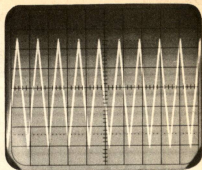
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Oscilloscopes

...HOW THEY WORK

Part Three...Circuitry...by Ian Hickman



This feature is taken from the last two chapters of a new book by this well-known author. Published by Newnes Technical Books the paperback is entitled *Oscilloscopes. How to use them. How they work.*

THE circuit diagram of the trigger processing circuits, time-base and X deflection amplifier of a modern dual-trace 15MHz oscilloscope, recently introduced by Gould (formerly Advance Ltd.), is shown in Fig. 19. It is a good example of the tendency noted earlier of modern oscilloscope designs increasingly to incorporate integrated circuits while retaining discrete components for those circuit functions where they are more appropriate. The various sections of the circuit are labelled (e.g. ramp generator, X output amplifier etc.) and detailed operation is described below, as it is typical of modern oscilloscope practice.

The trigger source switches, S502 and S503, connect the required trigger signal via the trigger coupling switches, S504 and S505, to the trigger buffer amplifier formed by TR601 and TR602. S502 selects the differential CH1 signal via R313 and R314 from IC301. S503 selects the equivalent CH2 signal via R363 and R364 from IC351. Where both S502 and S503 are selected, both of the above signals are disconnected and the single-sided input from the EXT TRIG input socket SKC is selected.

When the a.c. coupling switch, S504, is out, the trigger signals are directly coupled-through, but when this switch is in, a.c. coupling is introduced via C603 and C604 (C601 on external). TR601 and TR602 form a differential buffer amplifier with the d.c. balance controlled by the trigger level control, R602. The differential output from this stage is applied to the comparator, IC602, which has positive feedback applied by R623 to form a Schmitt trigger circuit. The changeover switch, S506, reverses the output from TR601 and TR602 to determine the trigger slope.

When both S504 and S505 are "in" (a.c. and d.c. in for TV mode), the junction of R603 and C610 is connected to the -11V supply. D601 and D608 are brought into conduction, while D602 and D604 are reverse biased. This diverts the output of the trigger amplifier away from IC602 into TR605, which amplifies the positive tips of the waveform only. TR605 is prevented from saturation by feeding back the peak detected synch pulses via TR607 and TR606 to the emitter of TR605.

These pulses are amplified by IC601b and applied via R617 and D603 to the Schmitt trigger, IC602. IC601a is used in conjunction with S504 and S505 to disable the sync separator when a.c. or d.c. is selected.

At the fast timebase sweep speeds, S262a is open and TR603 is cut off. However at speeds of 100µs/cm and slower, R608 is connected to +11V and TR603 is switched on. This effectively grounds C609 to introduce an RC integrating time constant into the sync pulse signal path in the TV mode to separate out the frame trigger.

The square-wave trigger output from IC602 is applied (with d.c. bias of Zener diode, D605) as the clock to the D-type TTL flip-flop, IC501a. A positive-going trigger edge will clock the bistable, driving Q low. In the waiting state, Q was high (+4.5V), turning on TR261 via R507 and R262, holding the input (and hence the output) of the operational amplifier, IC261, at 0V. This timebase amplifier is connected as a direct voltage follower.

When the trigger signal sends Q of IC501 a low, the timebase clamp transistor, TR261, is turned off. Part of the constant current generated by TR264 flows through the resistor network, R272, to charge C263 at a constant rate. The resultant positive-going linear ramp voltage generated at the input of IC261 is buffered by that amplifier to generate the low-impedance ramp output.

TIMEBASE RANGE SWITCH

The timebase range switch, S262, selects the tap point on the network, R272, to vary the ramp slope in the 1, 2, 5 sequence over a range of three decades. On all fast sweep ranges TR262 is biased off, but on ramps 0.5ms/cm and slower S262c connects R263 to +11V. TR262 is turned on and C264 is effectively connected in parallel with C263 to slow the sweep rate 1000 times.

The constant current in the ramp generator is derived from the current mirror circuit formed by TR263 and TR264. The variable gain control, R269, provides an approximate 3:1 range

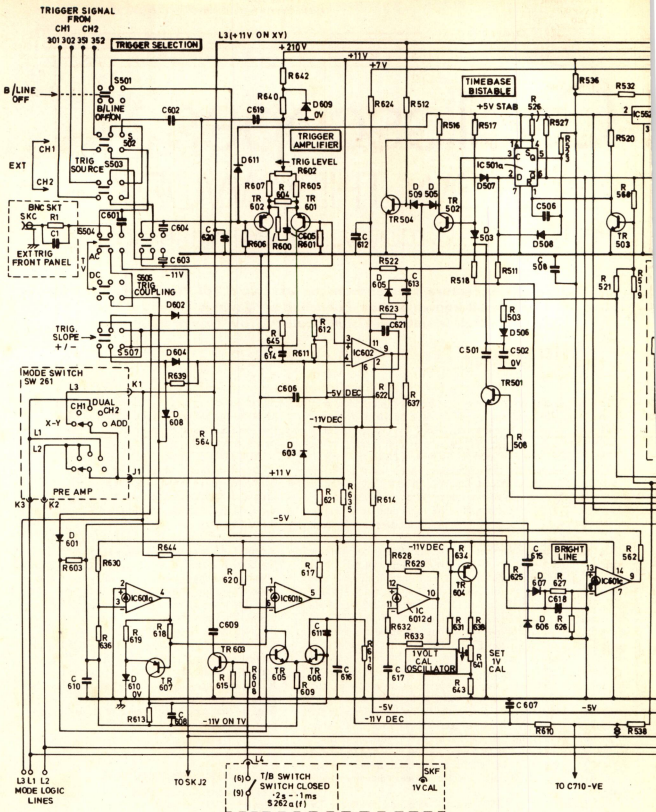
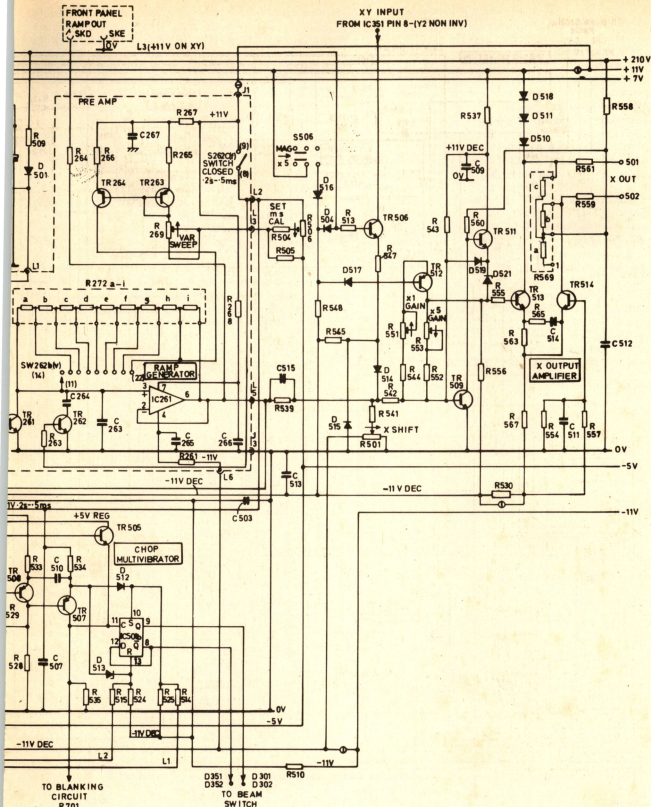


Fig. 19. X circuits of Gould OS255 oscilloscope, showing timebase generator-



trigger circuits and X-deflection amplifier (courtesy Gould Instruments Division)

of variation in this current; R506 provides a preset calibration control on the slow sweep rates, only when S262 is closed.

When the ramp reaches its maximum level, the negative bias introduced by R521 and R519 is overcome and TR503 turns on, driving the reset input of the timebase bistable low. As the bistable switches, Q returns high, and TR261 conducts to discharge the timing capacitor(s) and the sweep is complete. However, a hold-off action takes place to inhibit trigger signals during the sweep; this remains for a short period after a sweep to ensure that the ramp potential is fully reset before the next sweep can be triggered. As the ramp goes positive, D506 conducts to charge C502, reverse biasing D503 and turning on TR502. At the end of the sweep when the timebase bistable is reset, Q goes low and the D input follows via the action of D508 and R511. The ramp output returns rapidly towards 0V, but TR502 remains in conduction for a period determined by C502 and R518. Only when TR502 turns off can R516 and D507 take the D input high for the bistable to respond to the next clock input.

Transistor TR501 acts in a way similar to TR262 (described above) to introduce additional hold-off time through C501 on the slower half of the timebase ranges.

The brightline facility causes the timebase to free-run in the absence of trigger signals. The square-wave output from the Schmitt trigger, IC602, is coupled via C615 into the peak detector diodes, D606 and D607, to generate a positive-going signal into the negative input of IC601c, driving its output negative. In the absence of such trigger signals for a period determined by

TR513 and TR514. The collector output of this stage drives the X deflection plates of the c.r.t. The gain introduced by TR509/TR511 is defined in the $\times 5$ magnification mode by the input resistance, R539, and the feedback resistance, R552, with the preset, R553. In this mode the transistor switch, TR512, is biased off. However in normal $\times 1$ magnification mode, S507 is open and the current in R548 turns on TR512, introducing R544 with preset R551 as additional feedback to reduce the gain of the amplifier accordingly.

The X shift control, R501, introduces an additional bias input via R541 into the input of the shunt feedback amplifier.

POWER SUPPLY AND C.R.T. CIRCUITRY

The circuit diagram of the c.r.t. and power supplies section of a straightforward oscilloscope, the Scopex 4S6 is shown in Fig. 20. All the supplies are derived from a mains transformer with an untapped primary, providing operation from 210 to 250V a.c., 48–60Hz. The 6-3V secondary winding that supplies the c.r.t. heater is insulated to withstand the full -1.4 kV e.h.t. voltage applied to the c.r.t. cathode/grid circuit. All the d.c. supplies are derived from a single-tapped secondary winding; as is usually the case in inexpensive scopes, they are not stabilised. This will cause the deflection sensitivity of the c.r.t. to vary with mains voltage, but the design of the Y amplifier is such that its gain varies with mains voltage in the inverse sense, maintaining the overall gain constant at the calibrated value.

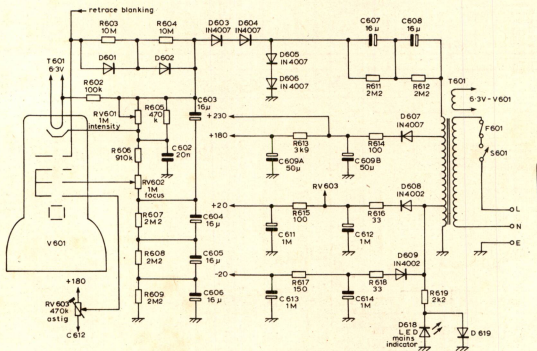


Fig. 20. Power-supply and c.r.t. circuit of Scopex 4S6 oscilloscope (courtesy Scopex Instruments Ltd.)

C618 with R627 and R626, the output of IC601c goes positive. When TR502 turns off at the end of the hold-off period, D509 conducts to turn on TR504, driving the set output low to initiate another sweep. This free-run condition is removed as soon as IC601c detects an output from the Schmitt trigger. It can be inhibited also with a positive bias via R625 if the BRIGHTLINE OFF switch S501 is operated.

The X output amplifier is formed by the shunt feedback stage of TR509/TR511 driving single-sided into the amplifier stage,

Intensity, focus and astigmatism controls are provided, the first two being mounted on the front panel. However, once set up during production test, the astigmatism control will need re-adjustment rarely if ever, so this control is a preset potentiometer mounted internally. ★

Diagrams in this series have been taken from the book and do not therefore conform with normal style for PE.

Semiconductor Curve Tracer

D. MANDELZWEIG

THE Transistor Curve Tracer was designed as an add-on unit for a dual-trace oscilloscope. N.p.n. and p.n.p. transistor I.c. versus Vce (as a function of Ib) are displayed, as well as diode and Zener diode curves. Icoo and Icoo Reverse can also be displayed as a function of Vceo. See full specification opposite. The prototype, using readily available components, costs approximately £30 to build, and when compared to a commercially available curve tracer, costing about 22 times that price, was found to be within 3% accurate, which is the basic accuracy of smaller dual trace oscilloscopes.

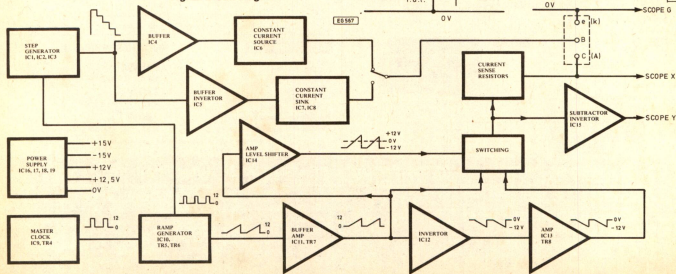
BASIC OPERATION

Refer to Fig 1. A ramp voltage is applied to the collector of the transistor to be tested, via a current sensing resistor Rc. The voltage across the transistor (Vce) is sensed via the X channel of the oscilloscope. A stepped current from a current source is applied to the base and the voltage across the transistor is ramped once for every current value. The actual current flowing in the transistor, Ic, is sensed as a voltage across Rc by the Y channel of the scope. Thus Ic is displayed as a function of Vce for different base currents. Icoo is displayed similarly, with a different value of Rc and with the base drive disconnected. The Diode curves are also similarly displayed, except that a bipolar signal is applied, so that If and Ir or Zener diode curves can be displayed.

BLOCK DIAGRAM

A block diagram is shown in Fig 2. This diagram shows the sub-sections of the unit, and the main components used in the sub-sections. With the aid of this diagram, and the circuit diagram, Fig 3, the circuit description can easily be followed.

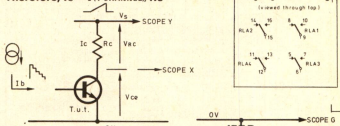
Fig. 2. Block diagram



CIRCUIT DESCRIPTION

The circuit functions as follows: IC9 and IC10 form the clock running at approximately 1kHz and a ramp generator respectively. CMOS 555 timers are used to reduce switching transients, which otherwise appear on the scope trace. These i.c.s have their own 12V supply, which was found necessary to prevent the transients affecting the trace. IC7a and TR7 buffer the ramp, and form a power amplifier for the ramp waveform. VR1 must be adjusted for maximum ramp and minimum space between ramps without affecting the ramp. VR2 must be adjusted for a peak of 12.5V at the emitter of TR7. This positive going ramp is split into 3 paths. One goes to relay contact 2 for use on n.p.n. transistors. The second path is to IC7b which inverts the waveform and feeds it to IC8a and TR8. These form a power amplifier for the inverted ramp to drive p.n.p. transistors via relay contact 2. VR3 must be adjusted for a negative peak of -12.5V at TR8 emitter. The third path goes to IC8b which is a level shifter/amplifier. The resultant waveform is used to test diodes. VR4 must be adjusted so that the 25V base-to-peak ramp waveform is centred about 0V.

Fig. 1. As shown, scope Y channel measures $V_{cc} + V_{bc}$. Y channel should measure V_{bc} to get I_c . Thus, IC6b has been included in the circuit to subtract V_{ce} from V_s to give a true V_{bc} . Therefore, $I_c = V_{bc} / R_c$





SPECIFICATION

Modes:	n.p.n. and p.n.p. transistor I_c versus V_{ce} curves. I_{ceo} and I_{ceo} Reverse for n.p.n. and p.n.p. Diodes and Zener Diode curves.
Transistor base currents:	4 ranges of 5 constant values each.
I_c current limit:	100mA and 500mA selectable.
Max. V_{ce} :	12V
Diode current limit:	24mA
Largest Zener diode that can be tested:	8V2

The output of IC10 (pin 3) is inverted by TR5, and the positive going pulses are used to clock IC3, which is a divide-by-eight counter divider. The Q5 output (pin 4) is used to reset the counter, so that it only counts to five. These five decoded outputs are used to control the transmission gates IC1 and IC2 so that each gate closes in turn, con-

tinually repeating the process. R1 to R11 and S5 form a precision divider chain, allowing voltage steps of 1V between 7.5V and 11.5V (with S5 in the position shown) and between 2.5V and 6.5V (with S5 in the other position) to be

- S1 NPN/PNP
S2 $I_b \times 1/x \times 10$
S3 MODE
S4 I_c 100mA/500mA
S5 I_b RANGE
S6 I_{ceo} REVERSE

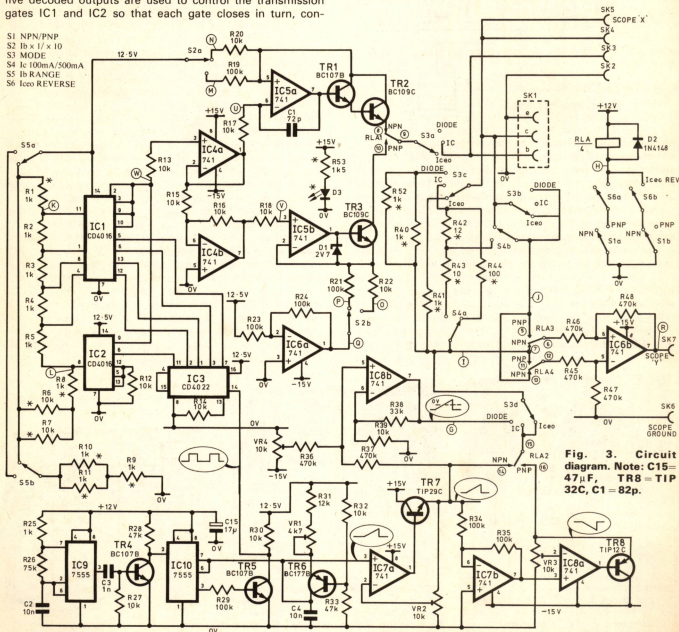


Fig. 3. Circuit diagram. Note: C15 = 47 μ F, TR8 = TIP 32C, C1 = 82p.

INTERCONNECTING LEADS & RELAY PIN N°S ARE ENCIRCLED
* MOUNTED ON FASCIA BOARD

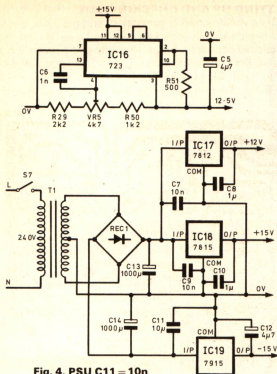


Fig. 4. PSU C11 = 10n

applied to the respective transmission gate inputs. The output of the gates are summed together, and the result of the sequentially closing gates (controlled by IC3) is a precise stepped waveform either 7.5V to 11.5V in 1 volt steps or 2.5V to 6.5V depending on S5. S5 is the base current range switch. In the position shown, it selects the 10µA to 50µA range (in steps of 10µA) and in the other position it selects 60µA to 100µA (also in steps of 10µA).

This stepped waveform is buffered by IC4a to avoid loading of the divider chain, and is fed to IC4b and IC5a. IC4b inverts the waveform and feeds it to IC5b. IC5a and IC5b with their associated components form a precision programmable constant current source and constant current sink respectively. The output currents are dependant on the input voltage and the values of R19/R20 and R21/R22. Here S2 is used to select one of two resistors in the current source and sink respectively, and is used as a base current

multiplier. In the position shown, the base current range is as mentioned above, and in the alternate position, the range is multiplied by 10, i.e. 100µA—500µA and 600µA—1mA, again depending on S5. The resultant stepped constant currents are chosen by relay contact 1 (the source for n.p.n. transistor, and the sink for a p.n.p. transistor) and is fed via S3a to the base of the transistor under test (TUT).

The power supply looks more complicated than may be thought necessary, but as mentioned above, it is not so. Three 3-terminal voltage regulators supply voltages as shown, and a 723 voltage regulator, adjusted via VR5 to a precise 12.5V, supplies current to the current source/sink and their associated components.

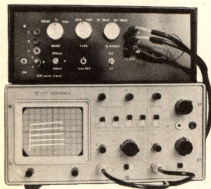
CONSTRUCTION

Although other methods of construction may be used, it is strongly advised that the unit is constructed using the p.c.b. layouts presented here. This will ease construction and make for a neater finish.

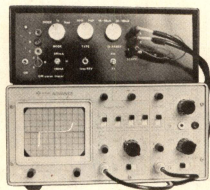
P.c.b. mounting switches may be obtained for all switches except S7, due to the different lengths of the switches, however, the following method of construction is adopted.

First solder a 3cm length of tinned copper wire to each tag of each switch except S7. Once this has been done, the case front panel must be drilled out as shown in Fig. 11. Fit the switches temporarily to the panel, and then fit the wire leads into the corresponding holes in the front panel p.c.b. Align the p.c.b. as close to the switches as possible, remembering to leave room for direct connections to S7, and for the Banana sockets. With the p.c.b. in this position, solder all the wires to the p.c.b. The p.c.b. and switch assembly can then be removed, and construction of the p.c.b. can be completed, leaving i.e.d. D3 and the connections for the Banana sockets and transistor socket for later.

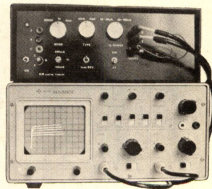
The PSU can be constructed next, and when completed, can be checked for correct operation. Before connecting a.c. to the board, check that all the capacitors are in the correct way round. If all is well, set VR5 for 12.5V on pin 3 of IC16, remove power, and continue construction of the main circuit. As usual start with the passive components and links, then solder in the transistors, and finally the i.c.'s. The prototype use i.c. sockets, and this practise is strongly recommended. Be careful when handling the CMOS i.c.'s as they are easily damaged. Finally fit the relay into its socket, and check the board carefully for solder splashes, and for correct orientation of the i.c.'s transistors, diodes and C15.



NPN transistor: At four horizontal positions, we have $4 \times 2V = 8V$. Second curve, i.e. $I_b = 20\mu A$, we have 1.7 vertical divisions, at 0.2V per div. which gives 0.34V. Therefore, $I_c = 0.34/R_{44} = 0.34/100 = 3.4mA$. Therefore $h_{fe} = 3.4mA/20\mu A = 170$.



4V7 Zener diode. Forward voltage = $0.6 \times 1 = 600mV$ (at point when current begins flowing). Reverse breakdown: 4V at initially, 5V at a reverse current of 1.4 div. $\times 5V/div$. over $500\Omega = 14mA$.



NPN transistor. 60µA to 100µA base current range.

Using stranded hook-up wire, preferably of different colours to aid checking, connect up the main p.c.b. and the front panel p.c.b., and solder lengths of wire to the boards for later connection to the PSU board. Leave enough wire between the main p.c.b. and the front panel p.c.b. to allow easy access to the main p.c.b. without having to remove the front panel p.c.b. at a later stage, if this becomes necessary.

SETTING UP AND CHECKING OUT

Once construction is completed, and the p.c.b. and wiring has been carefully checked, the unit can be set up and functionally checked. An oscilloscope and a meter will be required. First turn all the presets to mid-position, and switch S1 to n.p.n. S2 to 1b x1, S3 to 1c, S4 to 100mA and S5 to 10–50uA. Turn on the power, and check the outputs of IC18

PE

EP575

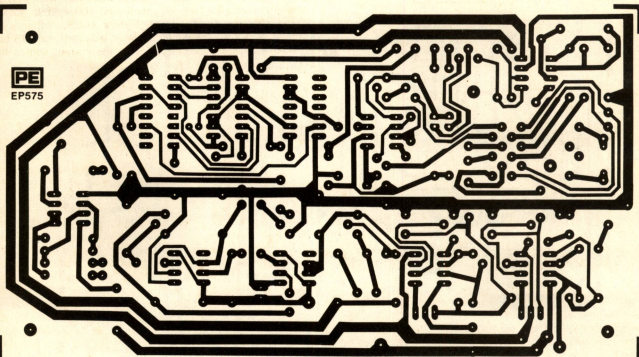
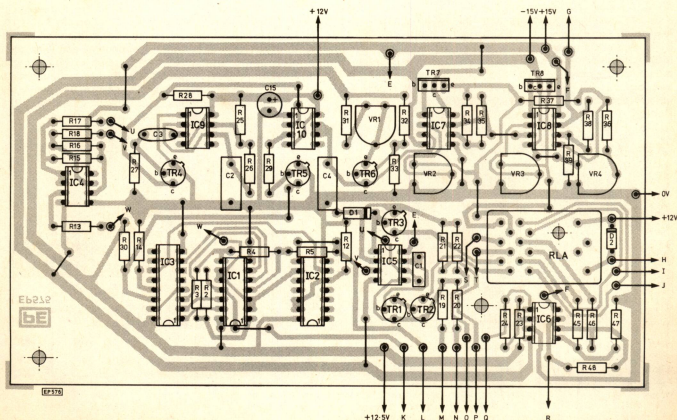


Fig 5. Main p.c.b. layout



and IC19. The voltage should be +15 and -15 volts respectively. Now adjust VR5 so that the voltage at pin 3 of IC16 is +12.5V exactly. Check that the voltage at the output of IC17 is +12V. With the oscilloscope connected to pin 7 of IC10 adjust VR1 so that the ramp part of the waveform is a maximum, without the point becoming flattened. Turning VR1 too far will indicated the above condition. Now adjust

VR2 so that the base-to-peak value of the ramp measured at the emitter of TR7 is +12V. Adjust VR3 for a negative ramp of -12V at the emitter of TR8. Adjust VR4 so that a ramp waveform with a base-to-peak value of about 25V appears at pin 6 of IC8b, centred at 0V. Check that a stepped waveform is available at pin 3 of IC1. Finally, if S6 is depressed, the relay contacts should pick up.

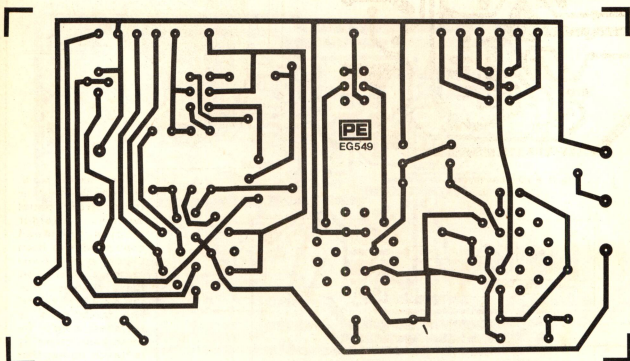


Fig. 7. Fascia p.c.b. layout

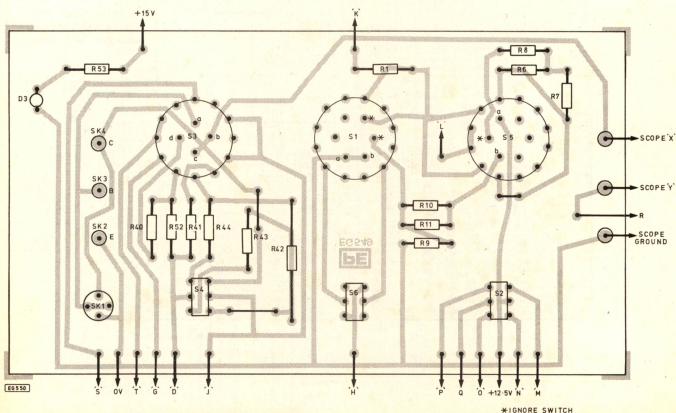


Fig. 8. Fascia p.c.b. component overlay

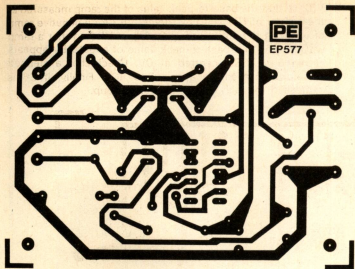
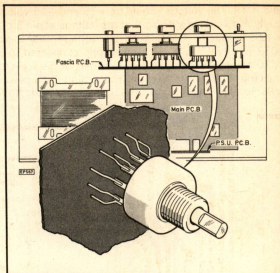


Fig. 9. PSU p.c.b. layout



The fascia p.c.b. obviates the need for tricky front panel wiring. Solder lengths of tinned copper wire to each tag of the front panel switches, then insert these switches into the p.c.b. and solder. The fascia p.c.b. is fastened solely by these connections. It is worth noting that insertion of the rotary switches into this board will be made easier if wires to the less accessible centre pins are left longer.

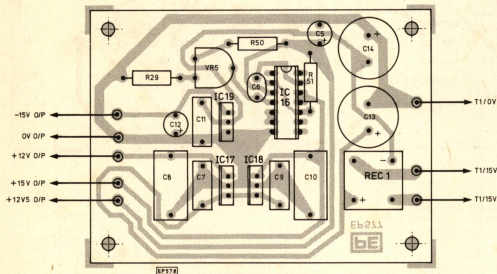


Fig. 10. PSU component overlay

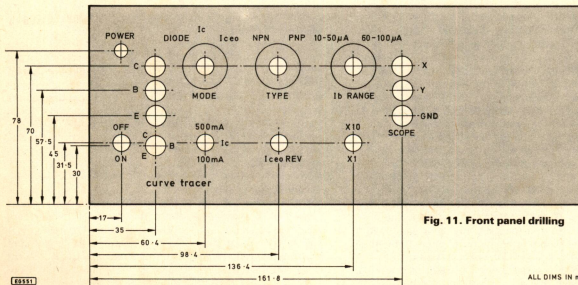


Fig. 11. Front panel drilling

ALL DIMS in mm

COMPONENTS...

Resistors

R1-R5, R8-R11, R40, R41, R52	1k $\frac{1}{4}$ W 2% (12 off)
R25	1k $\frac{1}{4}$ W 5%
R6, R7, R15, R16, R20, R22, R39	10k $\frac{1}{4}$ W 2% (7 off)
R12, R13, R14, R17, R18, R27, R30, R32	10k $\frac{1}{4}$ W 5% (8 off)
R19, R21, R23, R24, R34, R35	100k $\frac{1}{4}$ W 2% (6 off)
R29	100k $\frac{1}{4}$ W 5%
R26	75k $\frac{1}{4}$ W 5%
R28, R33	47k $\frac{1}{4}$ W 5% (2 off)
R31	12k $\frac{1}{4}$ W 5%
R36, R37, R45, R46, R47, R48	470k $\frac{1}{4}$ W 2% (6 off)
R38	33k $\frac{1}{4}$ W 2%
R42	12 2W 5%
R43	10 $\frac{1}{4}$ W 2%
R44	100 $\frac{1}{4}$ W 2%
R49	2k2 $\frac{1}{4}$ W 2%
R50	1k2 $\frac{1}{4}$ W 5%
R51	560m $\frac{1}{4}$ W 5%
VR1, VR5	4k7 min. horiz. preset (2 off)
VR2, VR3, VR4	10k min. horiz. preset (3 off)
R53	1k5 $\frac{1}{4}$ W 5%

Capacitors

C1	82p
C2, C4, C7, C9, C11	10n (4 off)
C3, C6	1n (2 off)
C5, C12	4 μ 7 tant. 25V (2 off)
C8, C10	1 μ (Siemens) (2 off)
C13, C14	1000 μ /25V (2 off)

Transistors

TR1, TR4, TR5	BC107B (3 off)
TR2, TR3	BC109C (2 off)
TR6	BC177B
TR7	TIP29C
TR8	TIP32C

Diodes

D1	2V7 Zener
D2	1N4148
REC1	2A 200V stack
D3	Red l.e.d.

Ic's

IC1, IC2	CD4016 CMOS quad switch (2 off)
IC3	CD4022 CMOS counter
IC4-IC8	μ A 1458 DUAL 741's (5 off)
IC9, IC10	7555 CMOS timers (2 off)
IC16	μ A 723 voltage regulator
IC17	μ A 78M12UC + 12V 500mA
IC18	μ A 7815UC + 15V 1A
IC19	μ A 7915UC - 15V 1A

Switches

S2, S4	DPDT (2 off)
S3	4P3W rotary
S6	DPDT biased
S7	SPDT
S1, S5	6P2W (2 off)

Relay

12V coil resistance	1k, 4 C/O contacts + base
---------------------	---------------------------

Transformer

15-0-15V	1 amp secondary
----------	-----------------

PLEASE NOTE

If difficulty is experienced in making the system operate reliably, it may be necessary to alter the Main p.c.b. so that R30-R32 are powered from +12V and not +12.5V. Link IC10 pin 8 across to top of R31 on p.c.b. and cut the main 12.5V track between top of R30 and IC3 pin 16, i.e. break just to left of IC3.

Also note that a link is required on Fascia p.c.b. to join the bottom end of R40 to bottom end of R52. S2a in Fig. 3 is shown at rest in wrong position, i.e. should point to R19.

BASE CURRENT VALUES

SWITCH POSITIONS	NO. OF STEPS	RANGE	STEP SIZE
S1 10-50 μ A, S2 x 1	5	10-50 μ A	10 μ A
S1 60-100 μ A, S2 x 1	5	60-100 μ A	10 μ A
S1 10-50 μ A, S2 x 10	5	100-500 μ A	100 μ A
S1 60-100 μ A, S2 x 10	5	600 μ A-1mA	100 μ A

USING THE UNIT

Connect the unit to an oscilloscope, set to X-Y mode. Connect the component to be tested via the socket or flying leads. Set the mode switch to the desired mode. If testing transistors, select the type, base current range, and the maximum allowable collector current for the type of transistor in use. Remember that $I_c = h_{fe} \times I_b$, so that the settings of switches S2 and S4 will be dependent on the transistor type. If the transistor data is completely unknown, always start with the lowest values of I_b and S4 set to 100mA. Adjust the X and Y inputs of the scope to give a suitable trace.

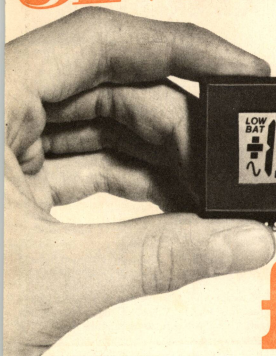
Label the front panel with Letraset as shown in the photographs (note that the collector and emitter 'C' and 'E' markings on the prototypes are incorrect for the Banana sockets—they have been swapped around. From the top it should read CBE). Fit S7, the l.e.d. D3, and the Banana sockets to the case. Glue the transistor socket to the case with an epoxy glue. Now fit the p.c.b. switch assembly into the case; tighten the switch retaining nuts, and bolt the main p.c.b. to the base of the case using spacers. Use tinned copper wire to connect the sockets and the l.e.d. to the p.c.b. Mount the transformer, the p.s.u. p.c.b. and complete all interconnections. Once the complete unit has been carefully

checked for wiring errors, a functional check and setting up can be carried out.

When testing a transistor for h_{fe} (mode switch in Ic position), 5 curves will be displayed. These correspond to set values of I_b , depending on the position of S2 and S5. Table 1 gives the possible combinations. The only thing that must be remembered is the values of R43 and R44 depending on the position of S4. Thus, to calculate the gain of a transistor at any V_{ce} with a set of base current, divide the Y voltage reading by the value of the resistor selected, and then divide by I_b . The diode currents and transistor leakage currents are found similarly by dividing the Y voltage reading on the scope by the selected resistor (500 Ω for DIODES and 1k for leakage currents, I_{ceo}).

The accuracy of the unit is dependent on the resistors marked as 2 per cent in the parts list. Ideally 1 per cent resistors should be used, but these seem hard to come by. A way to get round this is to buy a few more 2 per cent resistors than that required and then select by measurement those that have the closest value to the required value. R1 to R11, R19 to R22 are of particular importance, and it is also important that R45=R46=R47=R48 as close as possible. ★

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Positive Impedance Converters

A.B. BRADSHAW

MANY electronic experimenters are deterred from embarking on work involving the winding of low frequency inductors by the cost of pot cores and the obvious chore of winding many turns. This is a pity as a large area of interesting activity is denied them.

With the circuits about to be described this may now be remedied. Low pass, high pass, band pass and equaliser filters can be constructed using the positive impedance converter (PIC) to simulate the inductors (Fig. 1).

The upper frequency of this useful circuit is governed by the response of the op amps used, but the 741 will take care of the a.f. range.

The signal to noise ratio of the simulated inductance may not be as good as a wound component, but in the majority of applications this is not important, and could in any case be preceded by a low noise preamp for low noise filter applications.

The PIC is realised physically using two separate 8 pin d.i.l. 741 op amps, three resistors, one capacitor, a setting resistor (R_0). Using a balanced supply to the op amps $\pm 12V$, the setting resistor R_0 can be referenced to ground, in later arrangements an unbalanced configuration can be used. (See Fig. 2.)

It will be observed that 'looking into' port 1 an inductance is seen, the value of inductance we require is obtained by selecting the appropriate value for R_0 the setting resistor. Q values of 300 are obtainable with this arrangement.

Here $L=KR_0$ where K is called the conversion factor and

$$K = \frac{C R_1 R_3}{R_2}$$

With perfect op amps this would give

$$K = \frac{0.01 \times 10^{-6} \times 270 \times 10 \times 10^3}{5.6 \times 10^3} = 4.82 \times 10^{-6}$$

But due to imperfect op amps and worst case component tolerances, there is usually an error which can be determined by a test set-up.

SETTING UP A PIC

Wire the circuit on a small piece of Veroboard. Use a stable a.f. generator with an accurate dial, or use a frequency counter on its output. An output indicator having a high impedance input, or an oscilloscope with a 10X probe will be needed. Connect up as in Fig. 3. The resistors R_A R_B are to load down the output impedance of the generator (this is in series with C_0 and L). Let $R_B=100$ and $R_A=1k$.

For a first run set C_0 to be 10n, use two 5,000p silver mica 1% capacitors in parallel. Set the generator to 1kHz accurately, and turn its output level to maximum. Use a variable resistor of 500k for R_0 . Connect up the high impedance monitor or scope. Vary the potentiometer until a very sharp peak is obtained on the scope. The inductance of the PIC is now at series resonance with C_0 . Its inductance can be calculated from the expression:

$$\omega^2 = \frac{1}{LC_0} \quad \omega = 2\pi f$$

In the example $f=1kHz$ $C_0=0.01\mu F$ giving

$$L = \frac{1}{0.01 \times 10^{-6} \times 4\pi^2 \times 10^6} = \frac{10^2}{4\pi^2} = 2.533 \text{ henries}$$

The next step is accurately to measure the set value of R_0 .

A technique when setting up is to decrease the value of R_0 below resonance and replace the potentiometer with a fixed value, say 10% lower, and use a lower value of pot (perhaps 20k); if this procedure is continued then the circuit can be brought to resonance and R_0 will be known with good accuracy.

Having found the value of R_0 , the conversion factor can now be determined from:

$$L=KR_0 \text{ so that } K = \frac{L}{R_0}$$

Having now wired up the PIC circuit and arranged the test set-up, the value of K is calculated, we can now write:

$$L=KR_0$$

At this point it is worth while to substitute various accurately known fixed resistors for R_0 . Calculate then measure the resonant frequency. This will give some practice in using the set-up arrangement.

When attempts are made to simulate inductors embedded in, say, a filter network, we have to consider three situations:

Grounded Inductors

Note that with a $\pm 12V$ supply with centre at ground potential, the resistor R_0 is returned to ground, this is to give the op amps an input bias reference (Fig. 4).

If a single +24V rail is used with the op amps, an artificial centre point of +12V must be provided. This can be a low resistance resistive divider chain or a Zener diode +12V rail and R_0 will be returned to this point with a.c. decoupling.

Balanced Inductors

A balanced inductor is simulated as in Fig. 5. It will be observed that two PICs are needed for this one inductor, this uneconomical situation only occurs in simple filters, as will be shown in the next situation.

Here we find a snag, it is not possible in the balanced case to feed d.c. to the inductor and its simulating PICs, if the inductor is capacitively isolated. We can get around this by reconfiguring the filter as in Fig. 6.

Combined Inductors

This last case is shown in Fig. 7.

A surprise is in store here, for L_1 and L_2 can be simulated with two PICs only.

L_1 is simulated by PIC1— R_{01} —PIC2

L_2 is simulated by PIC2— R_{02}

In effect PIC2 is shared between L_1 and L_2 . Balanced d.c. supplies are shown for simplicity.

For many filters, if we know the component values we now have enough information to employ PICs for the inductors.

In the test set-up individual 741 op amps were advocated

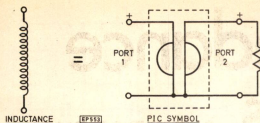


Fig. 1. PIC symbol for an inductor

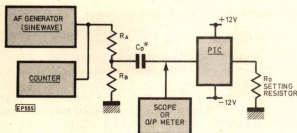


Fig. 3. Test set up for PIC

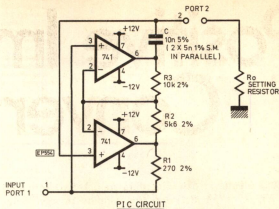


Fig. 2. Physical realisation of a PIC

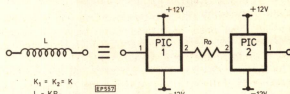


Fig. 5. (above) balanced inductor and its simulation

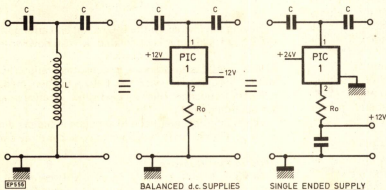


Fig. 4. (left) grounded inductor and its simulation

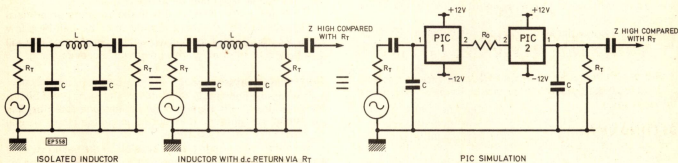


Fig. 6. (above) balanced and isolated inductor showing how to feed d.c. (via R_T) to the simulating PIC

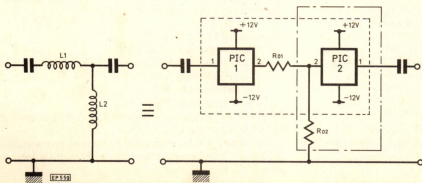
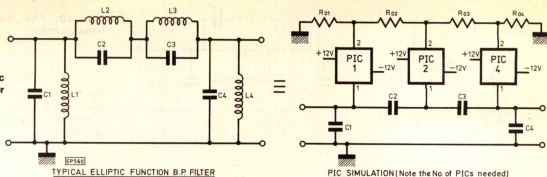


Fig. 7. (left) combined inductors and their simulation

Fig. 8. Typical elliptic function bandpass filter with PIC simulation



but if the MC1458CP1 is used with ± 6 volt supply it will give a $K=5.0 \times 10^{-6}$ and will cut the package count by a factor of 2.

In Fig. 8 a typical elliptic function bandpass filter with its PIC equivalent is shown.

BANDPASS DESIGN

The idea here is to define the shape of the bandpass response that is required. To do this, we need to know the bandwidth ratios.

This "shape" requirement is now compared to the data in the low pass tables, and one line of data is selected for best fit.

The selected low pass filter is called the "low pass prototype" (LP_p). See Fig. 9 for details of bandwidth ratios.

If we consider that the LP_p is resonated at $\omega_0=1$ for band centre, we can choose reciprocal values for the resonating pairs of reactances. Hence reciprocal values of capacitance are added in series with the inductors. Reciprocal values of inductance are added in parallel with the capacitors.

This completes the LP_p to bandpass transformation. See Fig. 10.

If the "Q" values are correct, **the bandpass filter has the same bandwidth at any attenuation as the low pass prototype.** The middle section of this bandpass filter looks rather untidy (and inconvenient). A transformation is performed on this in Fig. 11.

The network now looks much more manageable. The final step is to transform by scaling to the operating impedance and frequency.

THE "Q" CONDITION

Nothing has been said so far about the element "Q". When we select a LP prototype, it will meet the requirements using a definite branch "Q"; this is an important number and is known as "Q_b".

We modify the LP network by adding other elements, some in series and some in parallel to form the bandpass filter. The series elements have "Q" values which increase with frequency, the parallel elements have the reverse law, when scaled up in frequency.

To achieve the "Q" requirements in the final bandpass response, definite relationships exist between the "Q" values in the transposition stages.

$$Q_b = Q_c \times Q_p$$

Where Q_p =prototype low pass "Q"

Q_b =branch "Q" of bandpass filter

Q_c = "Q" of the desired bandpass response.

By using PICs and good quality capacitors, the branch "Qs" can be made high, and can thus be lowered by adding loss resistors if needed.

For medium and narrow % bandwidth designs, "Q" values

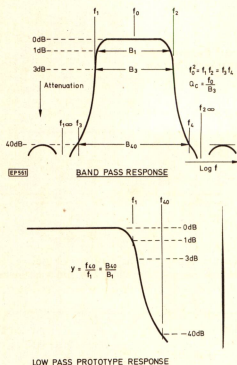


Fig. 9. Showing relationship between bandpass and lowpass response

larger than necessary are not often a problem, and usually sharpen up the corners.

The stopband attenuation is only slightly affected by the size of the "Q" values.

WORKED EXAMPLE 1

Using table A4-3

The following data is read.

$$A_s=40\text{dB}$$

$$\omega_s=3.542$$

$$C_1=0.988$$

$$C_2=0.0570$$

$$L_2=1.081$$

$$C_3=0.988$$

$$\omega_2=4.027$$

This is a single section, take f_0 centre frequency 1350Hz, "R" to be 220.

This network is converted to bandpass. Firstly normalising to $\omega_0=1$, this enables us to write reciprocals for the resonating components.

We next transform the middle section.

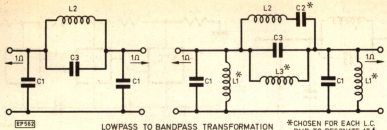


Fig. 10. The lowpass to bandpass transformation

Fig. 11. (below) the middle section of the bandpass filter is transformed. The five equations on the left show the working; through

- (1) let $x = \frac{L}{K}$
- (2) let $\alpha = 1 + \frac{1}{2x}$
- (3) let $\beta = \sqrt{\alpha^2 - 1}$
- (4) let $\gamma = \alpha + \beta$
- (5) let $L_0 = \frac{1}{\gamma + 1}$

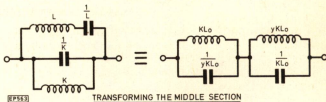
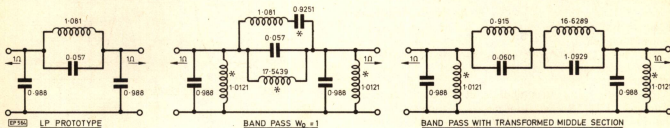


Fig. 12. (below) the worked transformation



When performing these step calculations, the display on many calculators rounds up the contents of the registers, so use the storage register and carry the process to the end; this should avoid any small errors which can occur at this stage.

The values of γ and L_0 are used in the transformation to give

$$\begin{aligned} KL_0 &= 0.9150 \\ \gamma KL_0 &= 16.6289 \\ \frac{1}{KL_0} &= 1.0929 \\ \frac{1}{\gamma KL_0} &= 0.0601 \end{aligned}$$

as in Fig. 12.

We now have to scale up to $f_0 = 1350\text{Hz}$ and the operating impedance of 220.

$$\text{From } A = \frac{R}{2\pi f} = \frac{220}{2\pi \times 1350} \text{ (inductance multiplier)}$$

and

$$B = \frac{1}{2\pi f R} = \frac{1}{2\pi \times 1350 \times 220} \text{ (capacitance multiplier)}$$

$$\text{Giving } A = 0.0259\text{H}$$

$$B = 0.53587\mu$$

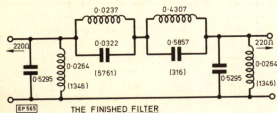


Fig. 13. (above) the finished filter and (right) the bandpass response when used as a sideband filter for single sideband reception. The send level is 0dBm

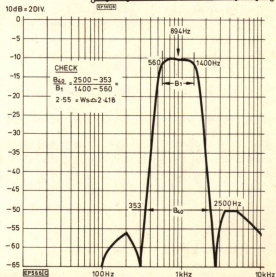
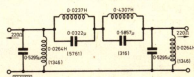
Multiply through by these multipliers to give the values shown in Fig. 13.

This network can now be made up. A word of caution is needed here. Set up the three PICs to have the same conversion factor (I used 5000p 1% and 10k 1%).

If necessary, to get the conversion factors equal, trim the values of R_3 or R_2 .

I used MC1458 op amps with $\pm 12\text{V}$.

The conversion factors trimmed to be $K = \frac{5.7155}{10^6}$



I selected the capacitors by tuning, using one of the PICs, and the setting resistors were 2%.

WORKED EXAMPLE 2

For simplicity we again use a single section. Attenuation in stop band 40dB. Band centre 894Hz. Terminating resistance 330.

From the charts we select

$A_s=40\text{dB}$
 $\omega_p=2.418$
 $C_1=1.910$
 $C_2=0.145$
 $L_2=0.905$
 $C_3=1.910$
 $\omega_2=2.762$

Table A4—1
 1dB ripple

For 40dB this data gives steepest cut. Calculate the reciprocals for the LP to BP at $\omega_0=1$

$L_1=0.5236$
 $C_2=1.1050$
 $L_3=6.8966$

Proceed to transform the middle section as in the first example to give

$Y=9.5155$
 $L_0=0.0951$
 $KL_0=0.6559$
 $YKL_0=6.2407$
 $\frac{1}{YKL_0}=0.1602$
 $\frac{1}{KL_0}=1.5247$

At this stage we have the bandpass filter prior to scaling. See Fig. 14.

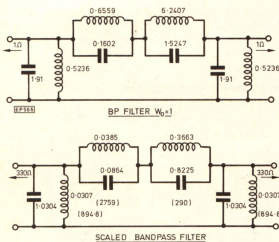


Fig. 14. (above) bandpass filter prior to scaling and (below) final filter

Scale to 330 and $f_0=894\text{Hz}$ using the scaling factors as below.

$$A = \frac{R}{2\pi f} = \frac{330}{2\pi \times 894} = 0.0587 \text{ (inductance multiplier "h")}$$

$$B = \frac{1}{2\pi f R} = \frac{1}{2\pi \times 894 \times 330} = 0.53947 \text{ (capacitance multiplier "μ")}$$

Final filter is shown in Fig. 14.

As in the first example, set up the three PICs. Set their conversion factors to be exactly the same. Trim R_2 or R_3 to achieve this condition.

Select the capacitors by either bridging them, or resonating with an accurately set up PIC.

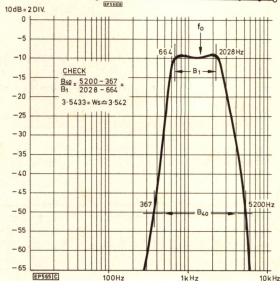
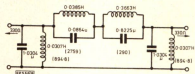


Fig. 15. Response of the final filter. Compare the bandwidth ratio (B_0/B_1) with the figure ω_s in the prototype

REFERENCES

Realisation of gyrators using op amp and their use in CR active network synthesis

PROC IEE Vol. 116 No. 11 Nov '69

Design of a.f. CR bandpass filters

by Haigh and Jeffers

Radio and Electronic Engineer Vol. 42 No. 8 '72

An active a.f. bandpass filter

by Davies

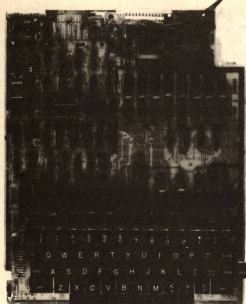
Radio Communication Jan '77

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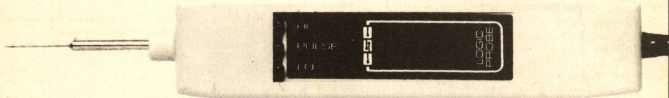
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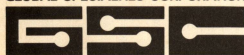
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Continuity METER

MARTIN KENT PE Continuity Meter DP500

THE present trend in electronics is for equipment to incorporate more functions in a gradually reducing space. This is a good policy until the equipment malfunctions and then the small space can add other problems. The DP500 Continuity Meter is intended to speed fault finding on crowded p.c. boards or complex cable looms.

The LE DPM200 panel meter is used to give four resistance measurement ranges providing accurate indication between 0.1Ω and $20M\Omega$. A low-power piezo-ceramic alarm is included to produce an audible output when the measured resistance falls below a preset level. Using the audible output, resistance may be assessed without the need to look at the display, leaving the operator to give full attention to the circuit under test. When a fault condition is found, the resistance may be measured accurately on the display. The threshold detection principle may be easily adapted for use in other instruments.

CIRCUIT DESCRIPTION

The Continuity Meter circuit diagram is shown in Fig. 1. Ratiometric resistance measurement is employed which eliminates the need for calibration by comparing the applied resistor to metal film reference resistors R1-R6.

Display=1000 $\frac{R_{\text{unknown}}}{R_{\text{reference}}}$

Protection against voltage being applied to the input of the panel meter is provided by R10 and TR2. In the presence of applied voltage TR1 turns on and shunts current through the PTC thermistor which increases in value to reduce the input current to a safe level.

Resistance measurement may be combined with an alarm output triggered when the input resistance falls below either a fixed or variable threshold.

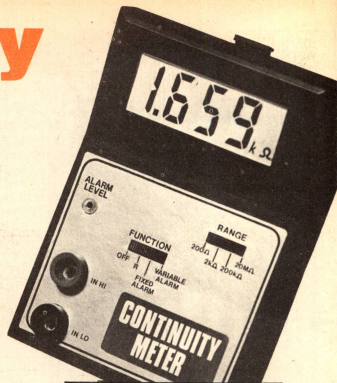
The piezo-ceramic alarm specified produces large audible outputs even at low operating voltage and current consumption is very small. The alarm is triggered by IC1 which compares the applied voltage on pin 3 against the threshold voltage on pin 2. During normal resistance measurement the voltage developed across the external resistor will be in the range $0-200mV$ and this is applied to the non-inverting input of IC1. This input has extremely high input impedance of typically $10^{12}\Omega$ such that loading of the input voltage will be negligible and accuracy of measurement will not be impaired. A comparator is essentially an operational amplifier operated in open-loop mode with high gain and the basic configuration is shown in Fig. 2.

The output of the comparator has two output states:

$V_{in} > V_{th}$ then output is high

$V_{in} < V_{th}$ then output is low

The LE DPM 200 panel meter has a very accurate $100mV$ reference voltage available between REF+ and REF-. Resistors R10-R12 form a potential divider across the reference voltage to form an extremely stable $10mV$ threshold for IC1 when the instrument is switched to fixed threshold mode. The $10mV$ figure represents a 0.5% level of the $200mV$ full scale, which is equivalent to 1Ω on the



FREE CASE PROJECT

SPECIFICATION

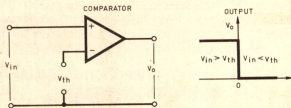
Function	f.s.d.	Resolution	Accuracy
Resistance	200Ω	0.1Ω	0.5%
	2kΩ	1Ω	0.5%
	200kΩ	100Ω	0.5%
	20MΩ	10kΩ	0.5%

Fixed Threshold: alarm sounds when applied resistance is less than 0.5% of range.

Adjustable Threshold: alarm sounds when applied resistance is less than threshold which may be set anywhere within the range.

200Ω range, 10Ω on the $2k\Omega$ range etc. The alarm will be triggered when the input falls below the level set by the range switch S2.

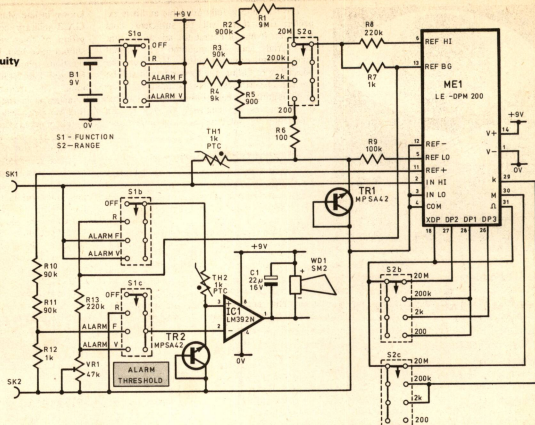
To provide increased flexibility of operation, a further position on the function switch enables the alarm to be generated when the input falls below an adjustable threshold. The bandgap reference voltage of typically 1.2V is available between REF BG and REF- on the LE DPM200.



ED 953

Fig. 2. Comparator action

Fig. 1. Circuit of Continuity Meter



EG562

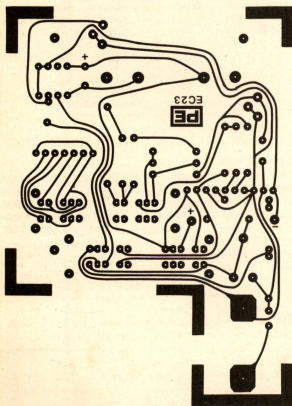


Fig. 3. Printed circuit board

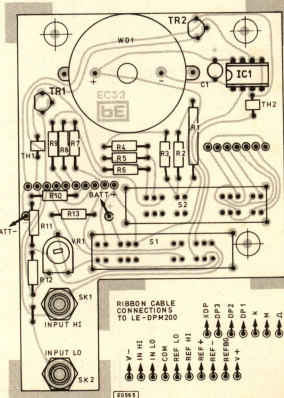


Fig. 4. Component overlay

COMPONENTS . . .

Resistors

R1	9M	
R2	900k	
R3	90k	
R4	9k	metal film 0.25%
R5	900	
R6	100	
R7	1k	
R8	220k	carbon film 5%
R9	100k	
R10	90k	
R11	9k	metal film 0.25%
R12	1k	
R13	220k	carbon film 5%

Variable Resistors

VR1 47k

Capacitor

C1 22M 16V tant. bead

Semiconductors

IC1 LM392N
TR1 MPSA42
TR2 MPSA42

Panel Meter

ME1 LE DPM200 (see special offer)

Thermistor

TH1 PTC 1k
TH2 PTC 1k

Miscellaneous

Instrument case
P.c.b.
Slide switches 4-pole 4-way (2)
Piezo-ceramic alarm SM2
Battery connector
Input terminals, p.c. mounting (2)
Ribbon cable
Self-tapping screws M3 (3)

A kit of components (excluding the DPM200 and case) is available at £12.95 inc. VAT from

Lascar Electronics Ltd., Unit 1, Thomasin Road, Basildon, Essex.

Resistors R13 and VR1 attenuate the reference and VR1 provides an adjustable threshold for IC1. The higher bandgap reference voltage is used to provide adjustment over the full scale of 0-200mV. The variable resistor may be

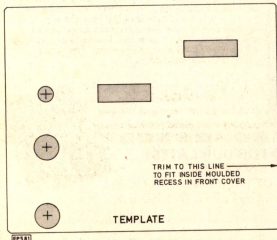


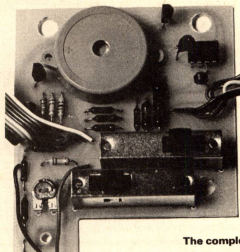
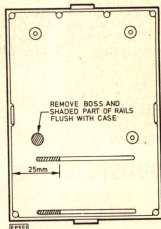
Fig. 5. Front panel template

adjusted when the instrument is in use such that the resistance threshold level may be altered to suit the circuits being tested.

The threshold detection techniques employed in the instrument could be used in most instruments using the LE DPM200 as the 0-200mV input to the DPM is a standard feature.

Switch S2b selects the appropriate decimal point on the display and S2c selects the correct resistance units on the display of either ohms, kilohms or megohms according to the selected range.

Fig. 6. Interior case cutting details



The completed board

CONSTRUCTION

The few components required for the Continuity Meter simplify construction which should be commenced with the resistors, then semiconductors. Position the switches and check that they are perpendicular to the p.c.b. before soldering. The input terminals, alarm unit and battery connector should then be fitted and the panel meter connected to the p.c.b. by the ribbon cable.

Connect the battery and with the function switch set to resistance measurement the display should indicate a 1 in the leading digit with other digits suppressed on each range. This is the overrange indication.

Switch to Fixed Threshold and when the input terminals are shorted the alarm should be triggered. Triggering of the alarm at the fixed and variable threshold levels may be tested with various resistors if desired.

When testing is complete, the p.c.b. may be secured in the case using three self-tapping screws and when the panel meter is located in the case lid the case may be clipped together. ★

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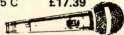


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Interfacing COMPUKIT

Part 6 D. E. Graham

THIS month we shall be looking at applications of the 6522 Versatile Interface Adaptor.

6522 VERSATILE INTERFACE ADAPTOR.

The third section of the Analogue Board consists of a 6522 Versatile Interface Adaptor. This is an extremely useful 16 register device, providing two programmable 8 bit input/output ports with handshaking and interrupt control, two 16 bit timers, and a serial input/output port. Fig 6.1 gives its schematic diagram.

Because of the complexity of this chip, we are forced to be highly selective in the treatment of it here, and have chosen to concentrate on the use of its timing and counting registers. In this context we will explore a number of practical applications including a signal generator, a digital frequency meter, a digital capacitance meter, and a real time clock.

For a treatment of aspects of the 6522 not covered here, the reader is referred to the bibliography at the end of the article.

6522 INTERFACE

Fig. 6.2 gives the circuit of the 6522 section of the Analogue Board. The device is selected by the BL2 line from the Decoding Module, giving it a base address of 61344 decimal. All external connections to the 6522 are made via the 16 pin d.i.l. sockets SK4 and SK5 on the Analogue Board (see Fig. 6.3 for pin connections). These have been made similar to those of SK3 and SK4 of the Decoding Module for the purposes of interchangeability.

The 6522 is a much more demanding device to interface than the 6821 PIA; and the timing and state of the chip select, $\overline{Q2}$ and R/W signals and ground connections are much more critical. For this reason, as suggested earlier, leads between the Analogue Board and the Decoding Module should be kept to a few inches in length. It is also necessary to enhance the earthing between the 6522 and IC2 on the Decoding Module, and between the UK101 earth track close to its expansion socket and the 6522. This is accomplished by soldering two leads as indicated in Fig. 6.4. For the same reason a 1n capacitor (C18) not provided for in the published p.c.b. design, but included in the kit supplied by *Technomatic Ltd.*, must be taken from the 6522 chip select line (pin 23) to ground (or Vcc). This is most easily accomplished by soldering the capacitor between pins 23 and 24 of the 6522 on the underside of the board. This capacitor has the effect of delaying the chip select pulse sufficiently to coincide with the arrival of the slightly misshapen and overworked $\overline{Q2}$ and R/W signals.

TESTING THE 6522

After checking the supply to the socket of IC1, the 6522 should be inserted, and the program listed in Table 6.1 run. This displays the states of the 6522's sixteen registers. Even after a Reset, these should contain a variety of data. If all registers read the same, then the chip is not interfacing

correctly, and checks should be made on pins 1, 20, and 22-38 of IC1 for a faulty connection or short circuit, either on the Analogue Board itself, or in the connections to the Decoding Module.

Once the registers appear to read correctly, data may be written to them using the program of Table 6.1. After displaying a readout of each of the 6522's registers, the program requests a register number, and data to be entered in it. And after performing the writing operation, will display the new states of all registers. When using this program in initial tests, it should be remembered that by no means all of the 6522's registers can be directly written to. To test the operation of the 6522 for both Read and Write operations, a convenient pair of registers to use is 2 and 3. These should each accept any integer from 0 to 255, and the program should display the value entered, on subsequent readout.

This is also an appropriate point to test the Reset function. Pressing the Reset button on the Decoding Module should reset certain (but not all) of the 6522's registers. As a test, it should be found that registers 2 and 3 are set to zero by this operation. Because of the complexity of the VIA it is advisable to reset it in this way before carrying out any of the experiments below using the two parallel ports or the timers; although as mentioned earlier, the Decoding Module Reset line is automatically activated at power-on.

USE OF THE PARALLEL PORTS

The 6522 has a pair of 8 bit input/output ports very similar to those of the 6821 PIA, though because of its extra provision of registers it is much easier to configure than the latter. Table 6.2 gives the configuration of the 6522's sixteen registers. From this it may be seen that registers 0 and 1 are the data registers for ports B and A respectively; note the reversal of order here. Registers 2 and 3 (the Data Direction Registers) determine whether each bit of port B and Port A Data Registers are set for input or output. This is very similar to the functioning of the 6821's Data Direction Registers.

To set port B for output on all 8 bits, the value 255 should be placed in register 2. This may be accomplished either by executing the command POKE 61346, 255, or by using the program in Table 6.1 to enter the data manually. In either case this should set the port B data pins (ie pins 9-16 of SK5) to zero volts. To output data through the port, that data should then be written to register 0 (at 61344). Thus for example the two commands:

POKE 61346, 255
POKE 61344, 15

will cause an output on port B of 15; or in other words, pins 16, 15, 14 and 13 of SK5 will read a one (about 4-5 volts), while pins 12, 11, 10 and 9 will read a zero (a few tens of millivolts). The configuration of port A follows a similar pattern, with the Data Register (register 1) at 61345, and the Data Direction Register (register 3) at 61347.

Fig. 6.1

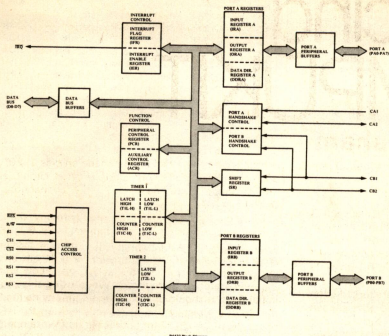


Fig. 6.1. 6522 Block diagram

6522

Fig. 6.2. 6522 section of the Analogue Board

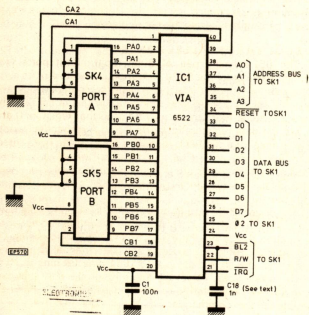


Fig. 6.4. Additional earthing leads to Analogue Board

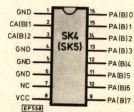


Fig. 6.3. Pin-outs of SK4 and SK5 of Analogue Board. SK4 carries Port A of VIA, SK5, Port B

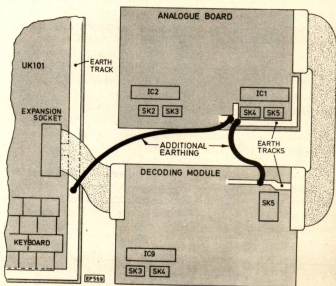


Table 6.1. 6522 handling program

```

80 REM INTERFACING UK101 PROGRAM 12
85 REM 6522 HANDLING PROGRAM
90 DIM A$(15)
95 P=61344
100 FOR A=0 TO 15
110 READ A$(A)
120 NEXT
130 PRINT
140 FOR A=0 TO 15 STEP 2
145 PRINT TAB(9);CHR$(140);
150 PRINT TAB(10);TAB(15);A$(A);
160 PRINT TAB(20);PEEK(P+A);TAB(25);CHR$(140);
170 PRINT TAB(26);A+1;TAB(31);A$(A+1);
180 PRINT TAB(36);PEEK(P+A+1);
185 PRINT TAB(41);CHR$(140)
190 NEXT
200 PRINT
250 INPUT "REGISTER":R
255 IFR=15 THEN 130
260 INPUT "DATA":D
270 POKE P+8,D
280 GOTO 130
300 DATA DBR,DRA,DDE,DDA,TIL,TIH,TIL,TIH
310 DATA TZL,TZH,SR,ACR,PCR,IFR,IER,DRA

```

Data input on each port is configured by setting the corresponding bits in the Data Direction Register to zero. Thus the commands:

POKE 61347,0
PRINT PEEK (61345)

will print the value of the data at port A. This will of course be a decimal representation of the binary states of the 8 input lines at pins 16-9 of SK4.

The 6522 does offer one extra facility over the 6821 PIA in the input mode: it may be configured to latch data in response to level changes in the peripheral control lines CA1 and CB1; and for details of how this is accomplished the reader is referred to the 6522 data sheets.

Since the pin connections to SK4 and SK5 of the Analogue Board have been made similar to those serving the PIA on the Decoding Module, devices such as the Joystick Control Box described in parts 2 and 5 of the series may be plugged directly into either of the 6522 ports if desired. In order to run the Joystick from port B of the 6522, for example, the Joystick header should be plugged into SK5 of the Analogue Board, and the Joystick program of Table 3.4 of Part 3 may be run with the following alterations:

130 P=61344
150 POKE P+2,0
160 Deleted

THE 6522's TIMERS

The 6522 contains two 16 bit counters which may be used for timing and/or counting operations. The two counters, usually referred to as T1 and T2 are somewhat different in operation, and each may be used in a number of different modes. Mode selection is carried out by setting the appropriate bits in the Auxiliary Control Register and the Interrupt Enable Register. See Table 6.3.

Timer T1 will only count at the Q2 clock rate, and may therefore only be used in timing operations. At the end of each count it may be variously conditioned to cause an in-

Table 6.2. The 6522's registers

Register Number	Address (Decimal)	Register Function	Nemonic
0	61344	Port B Data Register	DRA
1	61345	Port A Data Register	DRB
2	61346	Port B Data Direction Register	DDA
3	61347	Port A Data Direction Register	ddb
4	61348	Timer T1 Low Order Byte	TIL
5	61349	Timer T1 High Order Byte	TIH
6	61350	Timer T1 Low Order Byte	TIL
7	61351	Timer T1 High Order Byte	TIH
8	61352	Timer T2 Low Order Byte	T2L
9	61353	Timer T2 High Order Byte	T2H
10	61354	Shift Register	SR
11	61355	Auxiliary Control Register	ACR
12	61356	Peripheral Control Register	PCR
13	61357	Interrupt Flag Register	IFR
14	61358	Interrupt Enable Register	IER
15	61359	Port A Data Register	DRA

terrupt and/or to switch the polarity on PB7 (data line 7 of port B of the VIA, accessed through pin 9 of SK5). This counter may also be configured either in a one-shot mode, in which case only a single interrupt, or a single change in polarity occurs on PB7; or it may be configured in the free running mode, in which case a continuous series of interrupts may be produced, and a continuous square wave train of predetermined frequency may be output at PB7.

Timer T2 can be conditioned to count either at the Q2 rate, or to count the pulses appearing on PB6 (data line 6 of port B of the VIA, accessed through pin 10 of SK5). When a predetermined number of pulses from either source has been counted, T2 can cause an interrupt to signal this event. Timer T2 may also be conditioned to produce clock pulses for the 6522's shift register, though there is not the space here to discuss this latter feature.

The precise operation of the two counters is best understood with reference to specific applications. Timer T2 is the least complex of the two, and we will look at this first.

EVENT COUNTER

Since T2 is able to count incoming pulses on PB6, it may be used as a simple event counter. Only one bit (bit 5) of the Auxiliary Control Register controls the operation of T2. When it is at zero, T2 counts at the Q2 rate. Setting it to one on the other hand causes it to count pulses on PB6. For an event counter therefore, the value 32 should be loaded into the ACR (register 11 at 61355), so as to give a one at bit 5. For initial tests this may be done manually with the program of Table 6.1. It now remains to set the counter operating. This is accomplished by loading data into T2's latches. The latches are a pair of 8 bit registers that may be loaded by writing data to registers 8 and 9 of the VIA. For the purposes of the event counter it is probably easiest to write 255 into each of these. This may be done using the manual entry program. Writing 255 into register 8 will have no apparent effect, but when register 9 is written to, the data in the two latches will automatically be loaded into the counting registers of T2, and the count started. Reading registers 8

Register	Nemonic	FUNCTION OF EACH BIT							
		7	6	5	4	3	2	1	0
		T1 Control		T2 Control		Shift Register Control		Port B Latch Enable	Port A Latch Enable
12	PCR	CB2 Control			CB1 Control	CA2 Control		CA1	CA2
13	IFR	IRQ	T1	T2	CB1	CB2	Shift Register	CA1	CA2
14	IER	Interrupt Control	T1	T2	CB1	CB2	Shift Register	CA1	CA2

Table 6.3. Function of Auxiliary Control, Peripheral Control, Interrupt Flag, and Interrupt Enable Registers of the 6522

The circuit appears to give best results with $R = 1\text{ m}\Omega$ (giving a range from about 100p to about 100n, or $R = 100\text{ k}$ (giving a range from about 500p to 1m). Using lower values of R (eg 10k or 1k) to extend the range to higher values of capacitor unfortunately corrupts the mark to space ratio of the output, causing a false reading—although it might be possible to compensate for this somewhat in calculating the capacitor value. Another way to extend the range would be to use a longer waiting loop. A ten second loop, achieved by setting T to about 10000 in line 105, would extend the range at the high end by a factor of 10.

TIMER T1

Timer T1 is a slightly more complex device than T2, and makes use of four count and latch registers, where T2 uses only two. It also differs significantly in being able to count only at the Q2 rate, but is able to toggle PB7 each time a count is completed. Thus while T2 can be conveniently conditioned to count pulses on an external line (ie PB6), T1 can produce an external square wave output; and in fact by wiring PB6 and PB7 together (and taking a 1k Ω load resistor to earth) counters T1 and T2 could be cascaded to give a 32 bit counter. As with timer T2, we will use specific examples to illustrate its operation.

PRECISION FREQUENCY GENERATOR

With minimal conditioning operations T1 may be set up to produce a square wave output on PB7 (pin 9 of SK5) of frequency between 10Hz and 250kHz.

T1's counting mode is determined by bits 6 and 7 of the Auxiliary Control Register. See Table 6.7. With bit 6 at one, the counter operates in the free running mode, while a zero will put it in the one-shot mode. Bit 7 determines whether there will be an output on PB7 (bit 7 = 1) or not (bit 7 = 0). Incidentally when PB6 or PB7 are selected for use with T2 or T1 this takes precedence over their use as input/output data channels for port B.

From Table 6.7 it may be seen that placing a one at bits 6 and 7 of the ACR conditions T1 for continuous output on PB7. This is arranged in such a way that the output of PB7 is inverted at the end of each count.

It only remains to place the required values for the count in T1's latch registers. These are written to at registers 4 (low order byte) and 5 (high order byte); and as with T2, writing the high order byte automatically causes the two values to be loaded into the counter, and counting to begin. When T1's counting registers reach zero, the polarity on PB7 is inverted, and the contents of the two latch registers again loaded into the counters, and so on.

This operation may be set up using the manual entry program of Table 6.1. As a test, place 192 into register 11 (setting bits 6 and 7 of the ACR), followed by 2 into register 4, and 0 into register 5. This should produce a square wave output on PB7 of period 8 μ s.

The length of the period is given by the expression $T = 2(256A + B + 2)$ μ s; where A is the high order byte, and B the low order. The initial multiplication factor of 2 arises because of the toggling of the output effectively dividing the frequency by 2, and the additional 2 in the expression is associated with the time taken to load the counters etc.

It should be noted here that because of the configuration of the 6522's registers, the latches of timer T1 are written to at registers 4 and 5, but are read at 6 and 7. Data entered in register 4 actually appears on reading register 6, and similarly for 5 and 7. Reading registers 4 and 5 gives the current value of the count in progress. In the author's experience register 4 is particularly sensitive to good earthing of the 6522 and to good timing of chip select, Q2 and R/W, and it is advisable to check that data written into register 4

```
60 REM INTERFACING UK101 PROGRAM 15
70 REM 6522 DIGITAL CAPACITANCE METER
80 PRINT " DIGITAL CAPACITANCE METER"
85 PRINT " USING NE555 DRIVING PB6 OF VIA"
86 PRINT:PRINT
90 INPUT " R IN KILOHMS";R
100 P=0.1344
105 T=1110
110 POKEP+1,255
120 POKEP+8,255
130 POKEP+9,255
140 FORQ=0TO1:NEXT
150 T=PEEK(P+8)
160 Z=PEEK(P+9)
180 HZ=65535-T-2564Z
190 IFHZ<3THENPRINT"OUT OF RANGE":GOTO110
195 IFHZ<10THENPRINT,"LOW PRECISION RESULT"
200 C=700/(HZ*R)
210 C=1000*C
230 Q=4
240 IFINT(C/10^Q)<1THENQ=Q-1:GOTO240
250 C=INT(.5+C/10^(Q-1))*10^(Q-1)
260 PRINT:C;
270 PRINTTAB(22);"MANOFARADS"
300 GOTO110
```

Table 6.6. Digital capacitance meter program

Table 6.7. Functions of bits 6 and 7 of 6522 Auxiliary Control Register

bit 7	bit 6	Mode
0	0	T1 one-shot mode—Generate a single time out interrupt each time T1 is loaded. Output to PB7 disable
0	1	T1 free-running mode—Generate continuous interrupts. Output to PB7 disabled
1	0	T1 one-shot mode—Generate a single time out interrupt and an output on PB7 each time T1 is loaded
1	1	T1 free-running mode—Generate continuous interrupts and toggle output on PB7

does actually appear at register 6. As a test, try for example the values 0 then 1. If these fail to write in correctly, a check should be made that C18 is in place, and that the extra earth connections described earlier are properly made—some experimentation may be required here.

Using the 6522 to toggle the output on PB7 allows the implementation of very precise frequency generation; although of course only frequencies corresponding to integral numbers of counts may be generated, and ultimately the accuracy is limited by that of the UK101's 8 MHz crystal, which on the author's machine was about 1 part in 3000.

The program listed in Table 6.8 implements the signal generator. It first requests a frequency, and then outputs the nearest frequency available (rounding down), and at the same time prints out the exact frequency actually produced (within the limits imposed by the 8 MHz crystal). It will be noted when using this program that at the high end of the scale, at 100 or 200 kHz, the choice available is somewhat limited. In fact one can either have a 4, 6, or 8 μ s time period. At lower frequencies, much greater choice is available, and in the 1 kHz region for example, the frequency may be adjusted in steps of about 2 Hz.

FREQUENCY COUNTER USING T1 AND T2

One of the limitations to the accuracy of the frequency counter described earlier is the timing loop used to produce the one second delay during which the signal to be measured is counted. A more precise way to implement such a delay for higher frequencies is to use timer T1 in the one shot mode. T2 could then be made to count pulses on PB6 for the duration of T1's count. Stopping the count on T2 at the moment when T1 times out may be accomplished using a pair of NAND gates as shown in Fig. 6.7. The first gate (i.e. 1a) is used to invert the output of PB7 since this goes low rather than high during the count period. The signal to be tested is applied to the second gate (i.e. 1b) with the result that an output to PB6 is produced only during the counting time of T1.


```

80 REM INTERFACING UK101 PROGRAM 16
90 REM PRECISION SQUARE WAVE GENERATOR
95 REM USING 6522 VIA
100 P=61344
110 POKEP+1,192
115 PRINT:PRINT:PRINT:PRINT
120 PRINT:PRINT:PRINT,"PRECISION SQUARE WAVE"
130 PRINT,"GENERATOR - O/P ON PB7 OF VIA"
135 PRINT:PRINT:PRINT
140 PRINT:PRINT" FREQ REQUIRED (10 - 250000 HZ)"
145 INPUTP
150 IFP<10ANDP<250000THEN180
160 PRINT:PRINT" OUT OF RANGE - ENTER AGAIN"
170 GOTO140
180 N=(500000/P)-2
190 N1=INT(N/256)
200 N2=INT(N-256*N1)
205 H3=256*N1+N2
210 V1=500000/(H3+2)
215 PRINT:PRINT" EXACT FREQ GENERATED =";
220 PRINTF1;" HZ"
225 PRINTTAB(20);"OR ";
230 PRINT1000/F1;" H SEC"
235 POKEP+4,N2
240 POKEP+5,N1
300 GOTO140

```

Table 6.8. T1 frequency generator program

A t.t.l. wave train is then applied at point X, and the program in Table 6.9 run. This puts the value 160 into register 11 of the VIA, setting bits 7 and 5 high, and conditioning T2 for input on PB6, and T1 for the one-shot mode with output on PB7. T2 and T1 are then both loaded with the value 65535 (by placing 255 into both low and high order bytes), so setting in motion both counters. After a wait, the program POKEs the input signal frequency to the screen with auto-ranging units, then repeats the sequence.

As with the frequency counter described earlier, signals must be below 250kHz, and be t.t.l. compatible. And again a prescaler may be used to extend the upper limit. As a simple example Fig. 6.8 shows a 7490 configured as a divide by ten counter which effectively extends the range up to about 2 MHz. The accuracy of this frequency counter (± 20 Hz) is determined by the relatively short period (about 1/20 sec) during which the sample is taken. The only way around this with this method is to use software to extend the counting period to several count cycles of T1.

THE USE OF INTERRUPTS

One obvious application of the 6522 VIA in the personal computer context is the implementation of a real time clock. There are many ways of achieving this. About the simplest would be to set either T1 or T2 counting down at the $\phi 2$ rate, and inspect its count registers periodically, calculating the time accordingly. Such a procedure however will tie up the CPU rather more than is necessary, rendering the simultaneous running of other programs difficult if accurate timekeeping is to be achieved.

An alternative approach which does not suffer from this drawback is to use the 6502's interrupt facilities. An interrupt provides a way of drawing the CPU's attention to a particular situation at the instant that it occurs, without the CPU having to waste time in waiting loops, perpetually examining the state of various registers for a given occurrence.

The 6502 has two interrupt lines: the NMI or non-maskable interrupt, and the maskable IRQ line. When either of these is taken low by some external device, the CPU will shelve what it is doing and start the execution of a separate set of routines. When it has completed these it will return to where it left off, and continue until further interrupts are sensed. In the case of the maskable interrupt, the CPU will only take notice of the IRQ line going low if the interrupt mask flag in the 6502's own status register is not set (ie at zero). This is not the case with NMI, which cannot be masked in this way, and is acted upon as soon as the CPU has completed the instruction that it was engaged upon when NMI was taken low.

Interrupt facilities provided by the IRQ line may be used in a number of ways. As an example, they might be used to signal to the CPU that new data had arrived at a particular

```

80 REM INTERFACING UK101 PROGRAM 17
90 REM FREQUENCY COUNTER USING T1 + T2
91 FORZ=1TO16:PRINT:NEXT
92 PRINT,"T1 T2 FREQUENCY COUNTER"
94 PRINTTAB(11);" ("P" PRINTS - SPACE BAR EXITS)"
95 PRINTTAB(15)" ACCURACY +/- 20 HZ "
96 PRINT:PRINT:PRINT:PRINT
100 P=61344
120 POKEP+1,160
130 L2=255
140 L1=255
150 GOSUB4000
1600 P=(256*CL+C2)/(256*L1+L2+1.5)
1610 M=INT(P#1000000+.5)/100
1620 N1=0:IFM<1THENM=1000*N1:M=1
1640 GOSUB2000
1650 S=S+10
1660 N3="KHZ":IFN1<1THENN3=" HZ"
1670 GOSUB2220
1680 GOSUB3000
1690 GOTO100
2000 REM
2200 S=34110
2210 N=SECTRS(N)
2220 L=L-LEN(N$)
2240 FORM=1TOTL
2250 POKES=M,ASC(MID$(N$,M,1))
2260 NEXT
2265 IFPEEK(8+M)-32THEN2280
2270 POKES=M,32:M=M+1:GOTO2265
2280 RETURN
3000 REM
3020 POKES30,1
3030 POKES7088,253
3040 IFPEEK(57088)-239THENPEEK530,0:END
3050 IFPEEK(57088)-253THENPRINT:PRINT
3060 POKES30,0
3080 RETURN
4000 REM
4100 POKEP+8,255
4110 POKEP+9,255
4120 POKEP+4,L2
4130 POKEP+5,L1
4142 FORZ=1TO10000:NEXT
4150 C1=255-PEEK(P+9)
4160 C2=255-PEEK(P+8)
4200 RETURN

```

Table 6.9. T1-T2 frequency counter program

Fig. 6.7. Nand gates used in T1-T2 frequency counter

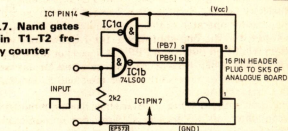
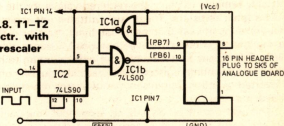


Fig. 6.8. T1-T2 freq. cnt. with $\div 10$ prescaler



port, and should be read in at the earliest convenience. Alternatively they might be used in the implementation of what is called an interrupt driven clock. Essentially this uses a counter to pull the IRQ line low at regular intervals, say 20 times every second. The interrupt routine can then count the number of times this occurs, and store the number of elapsed seconds, minutes and hours in RAM, returning to the main program when this has been done. Because interrupt handling routines are written in machine code, their execution times are usually very short. In the case of the interrupt-driven clock the CPU will only spend a few microseconds every 50 ms on timekeeping activities, so that this can provide a very efficient way of implementing a clock function on a microcomputer system.

Next month we will give a program which achieves this using the 6522 on the Analogue Board. But for now we will take a look at the general principles involved in using the IRQ interrupt on the UK101.

A SIMPLE INTERRUPT ROUTINE

As a simple illustrative example we will consider an interrupt program which just increments a given memory location when an IRQ interrupt occurs. And to keep the hardware very simple, we will take the $\overline{\text{IRQ}}$ line low with a push button connected between $\overline{\text{IRQ}}$ and ground (pins 1 and 8 of the UK101 expansion socket).

Interrupts can only be handled using machine code since there are no appropriate Basic commands, and in any case for interrupt servicing, speed of operation is usually of the essence. The central part of an interrupt program is the so-called interrupt service routine, to which the CPU is directed every time the $\overline{\text{IRQ}}$ line is brought low. This must first of all save the contents of the 6502's operating registers by pushing them on to the stack. The 6502 automatically saves its program counter and status register in this way, so that it is only necessary to include instructions for saving the Accumulator and X and Y registers; and even this is only necessary if their contents will be disturbed by the main body of the interrupt service routine.

In this case the main body of the routine will simply increment a given memory location. And when this is complete, the interrupt routine must restore the contents of the 6502's operating registers and finally execute a return to the program on which it was engaged prior to interrupt.

Table 6.10 gives a listing of an interrupt service routine which performs these functions. It is located at 0230 hex, and will cause the data stored at 022F hex to be incremented each time an interrupt is sensed.

Table 6.10. Disassembler listing of simple interrupt service routine	0230 48	PHA
	0231 8A	TXA
	0232 48	PHA
	0233 EE2F02	INC \$022F
	0236 68	PLA
	0237 AA	TAX
	0238 68	PLA
	0239 40	RTI

The first command PHA pushes the contents of the accumulator on to the stack. Next the contents of the X register are transferred to the accumulator, and are themselves pushed on to the stack for later retrieval. In this particular example these three commands are not in fact necessary, since the main body of the interrupt service routine does not use either the accumulator or the X register, and so their contents do not need to be protected in this way. The instructions are included here to illustrate the principle involved; and if the Y register is to be used in the service routine, then its contents should also be preserved in the same way.

The next command, INC 022F, increments the contents of 022F, while the three which follow, PLA, TAX and PLA, restore the contents of the X register and then the accumulator. Note that there is an effective reversal of order here, since the stack works on a first-in last-out basis. The final command, RTI, causes a return to the main program.

Before this interrupt service routine can be used, the UK101's interrupt system must be initialised in two ways. Firstly the 6502's IRQ mask must be cleared. This is performed by executing the instruction CLI. In the example we will do this by setting up a two instruction subroutine at 0228 hex. This involves placing 58 hex (CLI) at 0228, and 60 hex. (RTS) at 0229. We can then jump to this subroutine to clear the interrupt mask. Clearing the mask in this way must be carried out as a subroutine of the main program, since using a systems Reset on the UK101 to get back into Basic, automatically resets the IRQ mask again. This is why taking the IRQ line low has no effect during the normal running of Basic or machine code programs—IRQ is masked.

The second part of the initialisation procedure involves the

UK101's IRQ vector. This is a location in RAM (01C0 hex, 448 dec) to which the CPU jumps when it accepts an IRQ request. We must load this location with an instruction that directs it to the interrupt service routine described above, which is located at 0230 hex. To do this, locations 01C0, 01C1 and 01C2 are loaded with 4C, 30 and 02 hex respectively, representing the instruction jump (JMP) to 0230.

We are now in a position to test the IRQ interrupt. To do this, the data in Table 6.11 should be entered at the locations indicated, using the UK101 Monitor. This effectively enters the CLI subroutine, the interrupt jump instruction at the IRQ vector, and the main interrupt service routine described above. When these are in, the BASIC program in Table 6.12 should be run. Lines 120-160 of this use the $\overline{\text{USR}}(X)$ call to clear the interrupt mask. The program then prints out a running count together with the contents of location 022F hex. It will be seen that this latter changes after the IRQ line has been brought low using the push button. It will of course not simply increment by one, since during the finite time that the button is pressed, the CPU will complete many cycles through the interrupt service routine. It will also be noted that during the time that the button is pressed, the BASIC program will pause, resuming operation when it is released.

In more usual interrupt applications, the interrupt would be initiated by a device such as a 6821 or 6522 which can be instructed to take the $\overline{\text{IRQ}}$ line high again as soon as the CPU acknowledges the interrupt. This prevents the CPU getting involved in an endless loop of interrupts, and at the same time clears the way for fresh interrupt requests. This is the case with the interrupt driven clock to be described in the next issue.

	Address	Data	Function
Table 6.11. Table of data for IRQ interrupt test	01C0	4C	Replace Jump Instruction at IRQ Vector
	01C1	30	
	01C2	02	
	0228	58	Clear Interrupt Flag
	0229	60	
	0230	48	Interrupt Service Routine
	0231	8A	
	0232	48	
	0233	EE	
	0234	2F	
	0235	02	
	0236	68	
	0237	AA	
	0238	68	
	0239	40	

```

80 REM INTERFACING UK101 PROGRAM 18
90 REM BASIC PROGRAM FOR USE WITH
92 REM MACHINE CODE ROUTINES TO TEST
94 REM UK101 IRQ INTERRUPT
100 FORA=10101:PRINT:NEXT
105 PRINT,"IRQ TEST PROGRAM"
106 PRINT,"FOR USE WITH MACHINE CODE"
107 PRINT,"PROGRAM"
108 PRINT:PRINT:"IF UK101 HANGS UP, CHECK MACHINE CODE"
120 POKE11,40
130 POKE12,2
140 END(1)
162 PRINT:" IRQ MASK NOW DISABLED"
163 PRINT:PRINT
165 PRINT,"COUNT"; " 022F"
166 PRINT
170 PRINT,B;" "PEEK(559)
180 B=B+1
190 FORC=170500:NEXT
200 GOTO170

```

Table 6.12. Basic program for interrupt test

NEXT MONTH, as well as the interrupt driven clock, we will cover analogue to digital conversion, and discuss applications of the 8 channel A/D converter on the UK101 Analogue Board.

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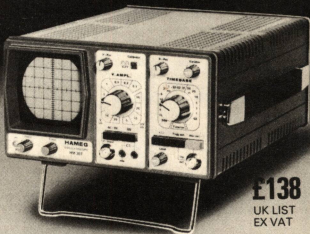
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GAMES are the main topic in this month's *Micro-Bus*; three games are presented, in BASIC for the Acorn Atom. The final topic shows how to obtain a continuously-changing display on the ZX80.

THREE GAMES

The three games programs contain a large number of abbreviations to keep them compact, and those not familiar with the Atom may therefore find them difficult to follow. The following list of abbreviations will be helpful in understanding them:

F. FOR
G. GOTO
GOS. GOSUB
IN. INPUT
N. NEXT
P. PRINT
R. RND
R. RETURN
T. TOP

The lower-case letters, after line numbers, are used as labels referenced by the GOTO or GOSUB statements.

SKI RUN

The first program, devised by *Tim Dobson* of Cambridge, simulates a ski run down a hill of random trees, with the aim of reaching a hut at the bottom of the slope. The skier is represented by a + sign, and the hut a white block; see Fig. 1.



Fig. 1. Display for the Ski-run game; the skier, shown as a '+', attempts to reach the white hut.

The game starts by asking you to enter the speed, and this can be in the range 0 (fast) to 500 (slow). Then the slope is displayed, and after a short delay the skier starts down the hill. The CTRL and SHIFT keys cause the skier to go left or right respectively, in order to avoid the trees. If the skier collides with a tree you fail, and if he reaches the bottom of the

screen safely, but misses the hut, he starts again at the top. If, however, he succeeds in reaching the hut, he can attempt a second run with more trees on the hillside.

PROGRAM OPERATION

The program, shown in Fig. 2, works by poking symbols directly to the Atom's screen memory. The variable S, contains the address of the start of the screen; a statement such as: S?P=30 pokes 30 into the Pth. screen location. First the program puts 15 trees at random places on the screen (line 25), and puts the skier at address R with a blank below him (line 30). Lines 40 to 100 then move the skier down the screen, testing for the CTRL and SHIFT keys, until he hits the hut or a tree. The expression ?#B001 gives a value of 191 if the CTRL key is pressed, and 127 if the SHIFT key is pressed. The old position of the skier is replaced by a blank (line 90), with a test to start again if the skier has reached the bottom, and the skier's new position is put in (line 100). Finally, there is a delay depending on K, the skill level.

Fig. 2. Ski-Run game, in BASIC, runs on an Acorn Atom.

```
5 P.$12"ski$880"run"
10 R=3:S=#8000:V=32
20 IN "SPEED(0-500)"K:U=15
25 SCLEAR0:P,T=1700:P=R.511:S?P=30:N.
30 H=5+39:7R=43:R?V=V
35 S?477=127:P,T=170700:N.
40 B=R:IF?#B001=191R=R+1:G.C
50 IF?#B001=127R=R+1:G.C
60 R=R+V
70 C?F=300.E
80 IF?R=127G.F
90 ?P=V:IF?#B1PFG.H
100 7R=43:P,T=170R.H:G.B
110 ?P=V:7R=15:P.530"BAD LUCK"
115 P."-YOU CRASHED ON"U" TREES":G.G.
120 ?P=V:#B1B=33:P.530"WELL DONE I"
130 P."YOU MADE IT WITH"U" TREES"
135 P."NOW TRY"U+2" TREES":U=U+2
140 P.I=170700:N.:G.X
150 IN "ANOTHER GAME"GT:IF?T.<78G.A
160 E.
```

SNAKE

The second game tests your reactions and manual dexterity, and was written by *Chris Cant* of Edinburgh. It shows a snake moving around on the screen whose direction of movement can be changed by the keys: W (up), A (left), D (right), and Z (down). Digits appear at random on the screen, and if the snake collides with one of these its length increases by the value of the digit; see Fig. 3. The point of the game is to increase the length of the snake without allowing it to collide with itself.

The program, Fig. 4, includes a section of assembler, for the 6502, which scans the keyboard and detects whether the keys W, A,



Fig. 3. The snake, about to swallow a digit and increase its length.

D, or Z have been pressed. If a key-press is detected the routine stores the corresponding symbol, <, >, or U, in memory location G (line 180). Initially, a snake consisting of a single > (code #3E) is set up moving from left to right across the screen (lines 300 to 330). The main program loop, lines 520 to 720, is then repeated for each move of the snake, until a collision occurs. Variables H and T contain the addresses of the head and tail of the snake, and array D contains offsets to move the snake in the four directions. The head is first moved (line 520), and the square it moves to is tested to make sure that it is not part of the snake (lines 525 and 527). The square is also tested to see if it contained a digit. If so, the score, W, is increased by the digit's value, and the tail of the snake is held still for this number of moves (line 536); the effect is to increase the length of the snake by the digit's value. Otherwise, the tail of the head is moved (lines 615 and 630).

The program then checks the keyboard by linking to the machine-code scan routine, LL0 (lines 640 and 670). Variables O and F are used as counters to determine how long the digits remain on the screen, and time until another one appears (lines 700 to 740). A random digit is poked to the screen in lines 760 to 790.

SNAKE STRATEGY

The snake coils around on the screen, so that if it moves off the top of the screen it will reappear at the bottom. Since the screen contains only 16 lines, it is very dangerous to travel vertically, and you are apt to bump into your own tail. Therefore, the best strategy is to move horizontally most of the time, only moving vertically for short periods to swallow digits. If you score more than about 40, congratulate yourself on excellent co-ordination!

Fig. 4. Snake game for the Acorn Atom. The assembler routine reads the keyboard; the BASIC section moves the snake.

```

5 REM SNAKE
10 DIM A(3),R(6),L(3),D(4)
20 C=1:J=1:R=3:J=3:P=21
30 D1=14000211F
40 G1=14000211F
50 G7=0:G76=0:G77=0
60 K1=1:R3=0015
70 K7=0:K76=0:K77=0
100 REM assembler routine
120 F=1:R=1:O=1:D1=1:R=1
130:ILLO LDY #10
140:LL1 LDY #6
150:LL2 STX #0000
160 LDA #0001
170 CMP G,X
172 BNE LL3
176 LDA R,X
180 STA G
190:LL3 DEX
200 BNE LL2
210 DEX
220 BNE LL1
230 STY #0000
240 RTS
250:J=1
300 B=4000:W=5:P=56:CLEARE
320 78022=43E:H=80022:T=6:J=2:W=32
330 C=0:P=1:J=5:S=5:P=40:Z=4:IFF
340 DO W=H:J=J+1:Z=Z+1
525 WAIT:Q=7:(H+B)
527 IFQ=210R=300R=600R=620G.e
530 IFQ=Q Y S=Q+30:W=H+E:S=S+E:O=0:F=1
533 I=0:WAIT:(T+H+B)=C?J
536 IPS C=1 S=S-1:G.A
600 WAIT:R=7:(T+B)
610:J=J+1:IFC?C=8 G.J
615 WAIT:(T+B)=Y
630 T=(T+D?J)=4E
640R=7:2:LINKLLO:IFP=2 G.S
670 WAIT:(T+B)=7G:J=0
690W=J+1:IFC?C>7G G.S
700W=0+1:P=1:IFC=0 G.t
720 7(P+B)=7:P=H+B+1P+2:0.0
740:IFC=0 U.0
760:RND=4812IF:IF(P+B)=>40 G.U
780 W=(2883)+1:O=H+B(7981P)+15-N
790 7(P+B)=4812P=0.0
800E=0:P.W= SCORED.
850 IN.1"ANOTHER GAME?IFG?IFG=CH?Y. G.20
900 P.P."CAN'T STAND THE FACE, EH?"
999 END

```

LAS VEGAS CRAPS

The third game simulates the excitement of playing the dice game Craps at Las Vegas. It was written by Alex van Someren of Windsor, and it uses the Atom's low-resolution graphics to plot the two dice; see Fig. 5.

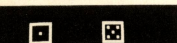


Fig. 5. Dice display for the Craps game.

PROGRAM OPERATION

The program for the Craps game is shown in Fig. 6. The program first asks you to make a bet. It then throws the dice, and you can watch your money increase or disappear depending on your luck.

The program uses a subroutine, r, to throw the dice and plot them on the screen, and this could be incorporated into many other games. P and Q are the numbers on each die, and S is their sum. Routine q, lines 380 to 450, plots a die at the current graphics-cursor position, and is called twice by subroutine r. Lines 100 to 200 form a jump table for the 11 different possible totals, 2 to 12, on the two dice.

Fig. 6. Craps game, in BASIC, for an Acorn Atom.

```

5 P.512"LAS VEGAS CRAPS..."
6 C=1:R=0:W=0:O=0:J=0:Z=0:Y=0:V=0:U=0:
10 DIM A(3):R=0
40 P."PLEASE BET TO END THE GAME..."
50 P."2,3,12 ARE LOSERS; 4,5,6,8,9,10 ARE POINTS."
60 P."
70 IN."ENTER YOUR BET?IF P=0 G.e
80 P."ENTER ARE YOUR DICE?"100R.T
85 W=0:J=0:O=0:Y=0:V=0:U=0
90 G.(10+10)80
100 G.t
110 G.t
120 G.t
130 G.t
140 G.t
150 G.W
160 G.P
170 G.t
180 G.P
190 G.W
200 G.t
210W.P."A NATURAL!"YOU WIN "P" DOLLARS"
215 G.A
220P.P."CRAPS!"YOU LOSE "P" DOLLARS"
230 P=F
240W=0+P
250 G.70
260P.P."A POINT? I WILL ROLL AGAIN"
270 11.#P=3:GOS.R.P.530"
275 IF S=7 G.t
280 IF S=8 G.300
290 P."NO POINT: I WILL ROLL AGAIN"(G.270
300 P."A WINNER!"WHAT PAYS "P" DOLLARS"
310 P=2*P:G.A
320P.P."ABOVE 12"
330 Q=ABOVE 12+1
340 S=P+Q
345 CLEARE
350 O=P:MOVH0.38:GOS.q
360 O=Q:MOVH40.38:GOS.q
370 R.8
380PLOT1.8:O:PL0T1.0.8
390 PLOT1.6:O:PL0T1.0.8
395 G.(10+1400)
400 PLOT.4:4:PL0T8.4.4:R
410 PLOT.2:2:PL0T8.4.4:PL0T8.6.6:R
415 GOS.405:G.410
418 PLOT.2:2:PL0T8.4.4:PL0T8.6.6:2:R
420 GOS.418:G.410
425 GOS.415:G.418
430 PLOT.2:2:PL0T8.4.4:PL0T8.6.6:4:G.420
435 PLOT.4:4:PL0T8.4.4:R
440P.P."YOU NOW HAVE $"R:E
445 IFR=0P."YOU ARE UNDER $"R:E
450 P."YOU CAME OUT AT $"R:E

```

When you are tired of tossing you can enter 0 for your bet, and see how you have fared overall.

CONTINUOUS DISPLAY FOR ZX80

The following program gives a continuously-updated display of the time on a ZX80; the same technique could be used to provide displays for games, simulations, or analysis programs. The program was submitted by Mr. Duggins of Birmingham, and what follows is based on his letter.

"Usually on the ZX80 information cannot be displayed on the screen unless the program is waiting for input from an INPUT statement, or has executed a STOP statement; this is because the display is software driven, and program execution cannot be maintained at the same time. To overcome this problem it was necessary to discover how the display operates."

DISPLAY ROUTINE

"The display routine is also the input routine, and is between addresses 013C and 01B5 (hex). The only useful part is a small subroutine at 01B0 (hex) which actually starts the display. A call to this routine generates one frame, down to the 24th display line. A second call to the routine must be made to finish the TV frame, and a vertical sync pulse must then be output to the TV. The duration of this pulse should be about 1ms, and the idea of the program is to use this time, once every 250 frames or 5 seconds, to update the display. The updating of the display actually takes slightly longer than 1ms, so there is an inevitable slight flicker.

DIGITAL CLOCK

"The digital clock program of Fig. 7 illustrates how to drive the display. The time is shown continuously, and is updated once every 5 seconds. It is accurate to about 2 minutes per day, but as the program stands there is no provision for a reset to 1 o'clock after 12 o'clock. The machine-code routine is entered by typing 'GO TO 250' and entering the codes shown in Fig. 8. Then set S, the seconds, M, the minutes, and H, the hours, to a convenient time using direct LET commands, type 'GO TO 10', and when the preset time is reached press NEWLINE to start the clock.

Fig. 7. Digital clock program for the ZX80 uses a machine-code routine to give a continuous display.

```

10 LET K=USR(17191)
20 CLS
30 LET S=S+5
40 IF S=60 THEN GO TO 100
50 FOR U=1 TO 2
60 NEXT U
70 IF M<10 THEN PRINT "TIME",H
75 IF M=9 THEN PRINT "TIME",H
80 LET K=USR(17232)
90 GO TO 20
100 LET S=0
110 LET M=M+1
120 IF M=60 THEN GO TO 200
130 GO TO 70
140 LET M=0
200 LET H=H+1
220 GO TO 70
250 FOR A=17191 TO 17243
260 INPUT I
270 POKE A,I
280 NEXT A

```

The BASIC part of the program is quite straightforward, except for the two USR calls. The first call, to address 17191, makes sure that there will be enough NEWLINE characters in the display file: from then on the machine-code is entered at 17232. The FOR...NEXT loop in lines 50-60 is used as a delay so that the TV is at the beginning of a frame, and the output from the ZX80 is therefore in sync with the TV; without this, the flicker is severe while the TV achieves sync.

MACHINE-CODE

The machine-code routine is shown as a decimal dump in Fig. 8. The display time depends on the byte at location 17201; in this case it is 250 frames. If more than 20 characters are to be printed by the routine, the byte at address 17196 should be increased by 1 for every extra character printed. With the program as it stands the machine code cannot be saved on cassette, but it only takes a few minutes to enter.

Fig. 8. Machine code display routine, in decimal, for the ZX80.

```

DECIMAL DUMP:
17191: 237 81 12 64 6 50 205 200 5 46
17201: 250 229 62 237 1 56 25 42 12 64
17211: 203 252 205 176 1 43 62 232 14 55
17221: 1 205 176 1 219 254 225 45 32 5
17231: 201 211 255 25 2420 6 90 16 254 211
17241: 255 24 214

```

PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1.45 each.

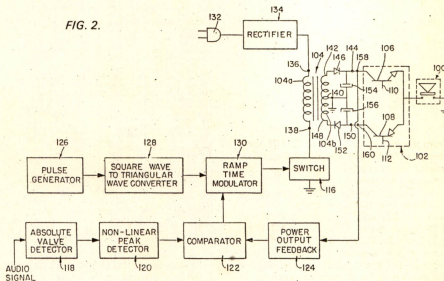
AMP RE-VAMP

Arguably the most radical re-think in amplifier design since the switch from valves to transistors is patented by Robert Carver in International PCT application WO 80/01023. The Carver M400 power amplifier is already on sale in the USA and is now starting to attract attention in the UK. A cube, 7in in size and weighing less than 9lb, it can deliver a total of 500 watts of audio power and costs only 350 dollars. Yamaha of Japan produced a similar design and has now taken a licence under the Carver patent.

Another PCT patent from Robert Carver from the USA (WO 80/02219) gives details of the hitherto secret "sonic holography" circuitry that is built into the Carver pre-amplifier. This will be dealt with in a future issue. Copies of both patents can be referred to, free of charge, in the Science Reference Library attached to the British Patent Office, Southampton Buildings, Chancery Lane. Copies of the patents may be purchased, but *beware*. Because the applications are not routine British cases (they were filed from the USA under the World Patent Cooperation Treaty), the normal British flat-fee purchase price does not apply. Each patent is well over 100 pages in length and full copies can cost nearly £20 each!

The Carver power amplifier achieves high efficiency and low cost, small size and light weight by the clever combination of several techniques, some known and some apparently new. In a conventional high power amplifier the mains transformer accounts for much of the size, cost and weight. To reduce the weight by reducing the winding, also reduces inductance and thereby increases idling current which wastes power as heat. Carver uses a small transformer and switches the primary in and out of circuit so that it draws just sufficient power for the programme being reproduced. Figure 2 shows a simplified circuit in which transformer 104 is of low inductance and weighs 1/40th the weight of the transformer of a conventional power amplifier of comparable power rating. When a voltage is applied across primary 104a, the current reaches a pre-set maximum of around 20 amps within a few

FIG. 2.



microseconds. Switch 116 then opens to leave energy stored in the transformer windings as a collapsing magnetic field. This stored magnetic energy is analogous to the electrical energy stored in the capacitors of a conventional amplifier. Switch 116 opens and closes at high frequency, e.g. 20 kHz, and the time for which the switch remains open during each 50 micro-second cycle is controlled by tracking the audio signal as it is amplified at 102 for reproduction by speaker 100. Comparator 122 compares the audio signals arriving via detectors 118, 120 with a feedback signal at 124, while switch 116 is controlled by pulses from generator 126.

In this way the current pulses passing through primary 104a are ramped up to maximum amperage as the load requirement increases. Full power is achieved in about 200 micro-seconds. Thanks to this fast response time, the storage capacitors 154, 156 can be kept small and inexpensive.

Figure 5 shows a more sophisticated system with the secondary of transformer 500 tapped to provide a stepped positive and negative voltage output. Control of stepping is by SCR 508 which in turn is controlled by the audio input signal. So as the audio input amplitude increases the SCR conducts for long periods and at higher voltage level. Diodes D511-521 keep capacitors 542-550 charged at pre-set levels by current flowing through the transformer secondary.

FIG. 5.

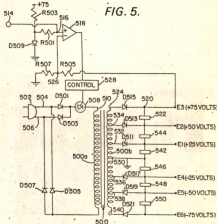
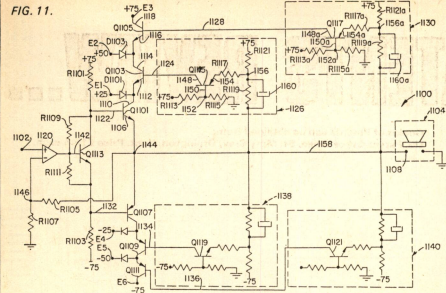


Figure 11 shows an amplifier 1100 designed to utilise such a stepped voltage power supply. NPN transistors Q1101, 1103 and 1105 amplify positive portions of the input signal; PNP transistors Q1107, 1109 and 1111 amplify the negative portions. Switches 1126, 1130, 1138 and 1140 control the conduction state of their associated transistors. When the signal voltage comes within a few volts of the 25 volt level, the first switch 1126 sends current to the base electrode 1124 of transistor Q1103. When the signal voltage comes close to 50 volts, the second switch 1130 makes transistor Q1105 conductive. In this way Q1101 takes power from the 25 volt line E1, Q1103 receives power

FIG. 11.

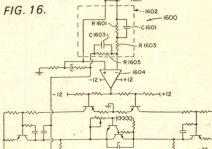


from the 50 volt line E2 and Q1105 takes power from 75 volt line E3. Voltage drop across the transistors is minimised and efficiency maximised.

Yet another feature of the Carver design is shown in Figure 15A. Crossover distortion is minimised by transistors Q1537, 1539, with diodes 1524, resistors R1520, 1521 and capacitor C1513. Together these form a bias network which keeps transistors Q1509 and Q1511 on the verge of conduction. Onset of audio input causes the transistors to conduct immediately without discontinuity of the audio output waveform.

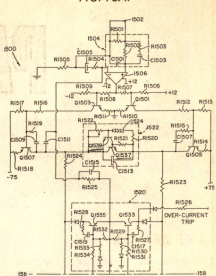
Finally Figure 16 shows another essential link in the Carver chain. One channel of the amplifier includes a network for shifting the phase of the incoming audio signal by 180°. Carver says that statistical analysis

FIG. 16.



of stereo programme material has shown that for most of the time the information in the left and right channels is similar and in phase. As a result conventional amplifiers place a heavy burden on one side of the

FIG. 15A.



power supply while leaving the other side idle. By inverting the phase of one channel, and thereafter processing the two channels in out-of-phase relationship, there is a marked gain in efficiency. Both positive and negative excursions of the power supply during each power cycle are fully employed. The inverter network of Figure 16 consists of capacitors C1601, 1603 and resistors R1601, 1603 and 1605 to drive the inverting terminals of operational amplifier 1604. Preferred values for the network components are listed towards the end of the book-sized patent document.

First reports suggest that the Carver amplifier works well. But r.f. interference created by the rapid duty cycle switching may prove a problem in the UK, where radiation regulations are very strict.

Readout...

A selection from our Postbag

Readers requiring a reply to any letter must include a stamped addressed envelope.

Opinions expressed in Readout are not necessarily endorsed by the publishers of Practical Electronics.

Frustration with Integration . . .

Sir—With reference to R. W. Coles introduction to the SG 1547 Power Supervisor in Semiconductor Update, March 1981 issue, I think a very interesting subject has been intentionally or unintentionally touched on. This being the design of discrete power supplies, or for that matter the design of anything discrete. Everything that is said in the first paragraph is very true, and the satisfaction gained from designing a piece of electronic apparatus and sorting out its problems must be likened to the latest "in thing" of computing and debugging programs.

However the crux of the matter is, as R. W. Coles says, why bother designing PSUs etc. when there are available a plethora of i.c.s which can do the job—but where is the satisfaction! Who, if anyone, would design for their own purposes discrete monostables, counters, op-amps etc. With such a range of i.c.s available, the average constructor has got to a stage where it's easier to select an i.c. rather than build it discretely, to see how it works and check on his own design theory, rather than accept a "black box" attitude.

Personally I have thought that since the 1970s that many constructors have moved away from the design table and have, rightly or wrongly, selected an i.c. for the job. This results in frustration when there is a problem to be tackled and there isn't an i.c. suitable for

that task. Like, for example, low supply voltage applications and low voltage dropout regulators in high quality audio.

Of course there is the other side of the coin—integration has opened up very interesting areas for the constructor which 10 years ago just would not have been considered. So while i.c.s have enhanced the constructors techniques, I think in some ways there has been a step in the wrong direction, away from designing at the discrete level. This situation could be helped with more articles in PE on design principles and concepts.

Geoffrey Pike,
Co. Antrim.

Point taken, Mr Pike, though there are other factors which we have to bear in mind when considering a project for publication. Cost, degree of constructional difficulty and the performance of the end product rank high on our list of priorities. This does mean as you pointed out that a large number of our projects are based around i.c.s. However, judging by the letters we receive, a good proportion of our readers DO know what goes on inside the "black boxes".

Our forthcoming series on Digital Design will help others to get to grips with the subject.—Ed.



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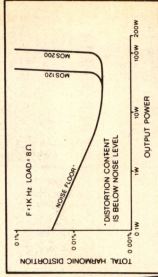
Model	Output Power RMS	Distortion Typical at 1kHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
MOS120	60W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£25.88 + £3.88
MOS200	120W into 4-8Ω	0.005%	20V/μs	3μs	100dB	£33.46 + £5.02

BIPOLAR

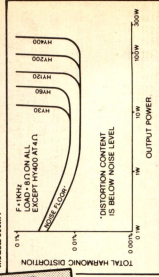
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Model	Output Power RMS	Distortion Typical at 1kHz	Slew Rate	Rise Time	Signal/Noise Ratio DIN AUDIO	Price & VAT
HY30	15W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£7.29 + £1.09
HY60	30W into 4-8Ω	0.015%	15V/μs	5μs	100dB	£8.33 + £1.25
HY120	60W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£17.48 + £2.62
HY200	120W into 4-8Ω	0.01%	15V/μs	5μs	100dB	£21.21 + £3.18



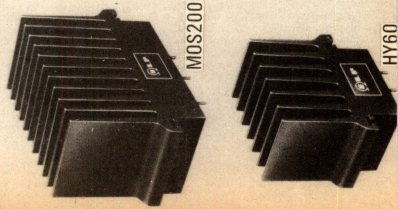
Load impedance both models 40:∞ Input impedance all models 100kΩ 40:∞ Input sensitivity both models 500mV 15Hz-100kHz -3dB



Load impedance all models 40:∞ Input impedance all models 100kΩ 40:∞ Input sensitivity all models 500mV 15Hz-50kHz -3dB

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MOS200

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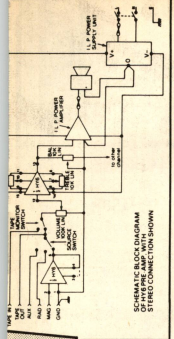
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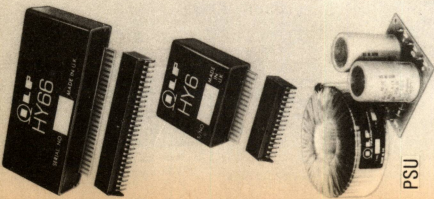
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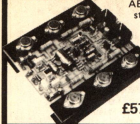
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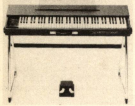
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21	4	8	8.79	1.60
51	5	10	10.85	1.80
117	6	12	12.29	1.72
88	8	16	16.45	1.96
89	10	20	18.89	1.84
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Ref.	50V	25V	Price	P&P
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103	1	2	4.57	1.20
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108	4	8	12.92	1.72
107	6	12	18.77	1.84
118	8	16	22.29	2.20
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127	2	4	8.36	1.60
128	3	6	11.77	1.72
129	4	8	13.77	1.96
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120	6	12	18.87	1.96
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Pri 220-240 volts

Ref.	12V	24V	12-0-12V	Price	P&P
111	0-5	0-25	2.42	0.95	113
213	1-0	0-5	2.90	1.00	64
71	2	1	3.85	1.00	4
18	4	2	4.48	1.20	53
85	5	2.5	6.16	1.20	87
70	6	3	6.89	1.20	93
108	8	4	8.10	1.44	83
12	10	5	8.83	1.60	95
10	12	6	9.88	1.44	109
17	16	8	11.79	1.72	805
187	20	10	13.79	2.04	575
226	30	15	19.72	2.04	1015
	40	20	40.41	0.84	220, 240

SPLIT BOBBIN Pri 0-240-Sec

12-15-20-24-30V Volts out 3, 4, 5, 6, 8

9, 10, 12, 15, 18, 20, 24, 30V or 12-0-12

or 15-0-15V

Ref 1009 - 1 Amp **E2-98**, P & P £1.10

Ref 010 - 2 Amp **E4-85**, P & P £1.10

open frame fitting. Other types available.

TRANSFORMERS END OF LINE OFFERS

M616 - 240V: 13-0-13 1A 12V 150ma £1.50 66p

M708 - 6K to 3D matching transformer 5W 90p 40p

B7 - 0-110-120-240V, Sec 20V 1A £1.80 66p

M679 - 120V - 2.36V 1.6A £3.00 78p

M865 - 100V Line to 4Q 10 watts £1.90 66p

M1020 - 0-240V 12-0-12V - 50ma 75p 41p

M1126 - 120/240V 0-9V - 1A £1.79 71p

AUTO TRANSFORMERS

Voltages available 105, 115, 120, 200, 210, 220, 230, 240

Ref.	VA	80	115	120	200	210	220	230	240
113	80	75	4.41	1.20					
64	150	5	5.89	1.20					
4	150	5	30.08	1.44					
53	150	5	12.09	1.84					
87	150	5	20.64	2.20					
83	1500	25	0.41	0.84					
95	2000	38	31.31	0.84					
109	2000	38	66.13	0.84					
805	4000	84	84.85	0.84					
575	5000	98	45.45	0.84					
1015	220, 240								

15V 0-7 (5V)

171 500mA 1.20 0.52

172 1A 2.30 0.92

173 2A 3.95 0.90

174 3A 4.13 0.99

175 4A 6.30 1.10

MAINS ISOLATORS (SCREENED)

Pri 0-120-0 100-120V 120, 220, 240V. Sec 60-60-135-60V twice to give 55, 60, 110, 120, 125, 175, 200, 220, 225, 230, 235, 240V.

Ref.	120	220	Price	P&P
70	20		4.54	1.20
89	40		7.37	1.20
10	100		8.38	1.44
32	100		32.03	2.72
152	250		14.61	2.04
154	500		22.62	2.20
155	420		32.03	2.72
156	1000		40.82	0.84
157	1000		56.52	0.84
158	2000		67.99	0.84
159	3000		96.33	0.84

*Pri 0-240V Sec 115 or 240V

State sec volts required.

SCREENED MINIATURES

Ref. 238 200 3-0-3

212 1A 1A 0-6-0

13 13 13 13 13 13 13 13 13 13

235 330 330 330 330 330 330 330 330 330

207 500 500 500 500 500 500 500 500 500

208 1A 1A 0-6-0

236 200 200 200 200 200 200 200 200 200

237 7000DC 120 120 120 120 120 120 120 120 120 120

221 500 500 500 500 500 500 500 500 500

209 1A 1A 0-6-0

234 1A 1A 0-6-0

239 50 50 50 50 50 50 50 50 50

8 437 437 437 437 437 437 437 437 437

NEW RANGE TRANSFORMERS

0-36-48 twice to give 36-36-48-0

48V 60V 72V 84V 96V

Amper 5 4 330 4-88 0.76

0 5 430 0-88 0.76

2 432 13-35 1.31

3 433 16-17 1.40

4 434 20-26 2.11

5 435 29-30 2.47

6 436 36-48 2.11

8 437 40-03 0.84

TELEPHONES

Latest model telephone, brand new, boxed

2-tone grey £11.50 + P&P £1.20 + VAT

BURGULAR ALARM

Ultra-sonic 20ft range to insulation coils. Key operated

built in siren (external bell can be added)

Looks like a speaker. £98.00 £2.00 P&P

VAT.

"Educational" Meters (Moving coil)

0-10A, 0-15V, 0-30V

Free standing large scale easily read meters

with top screw terminals for quick connections

Size 75 x 75mm scale £4.50 P&P 66p + VAT

OTHER PRODUCTS

ABS Plastic Boxes: Inset brass nuts, slots to take P.C. cards. Boards from fitting lid.

PB1 - 80mm x 62 x 40mm P&P

PB2 - 100mm x 75 x 40mm P&P

PB3 - 120mm x 100 x 45 £1.04 50p

PB4 - 215mm x 130 x 85 £2.68 + VAT

Bridge Rectifiers

100V 25A £1.80

100V 50A £2.20

200V 2A .52

200V 4A .78

400V 1A .25

400V 4A .36

400V 6A £1.44

500V 12A £3.60

P&P 20p VAT £1.50

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Plugs into 13 amp socket 6-7.5, 9V 300mA £5.10 + P&P

60p + VAT.

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43 x 43mm 82mm x 78mm

0-50uA 6.20 0-50uA 6.70

0-500uA 6.70 0-500uA 6.70

0-1mA 6.70 0-1mA 6.70

0-30V 6.70 0-30V 6.70

Vij ind. Panel 48mm x 48mm of

40mm x 40mm 250 A fad or Edge-

type centre zero 39 x 18mm £2.60

Carriage 76p VAT 15%

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S101 (HP7)	1.25	0.5A	£3.06
Sub C (HP11)	1.25	1.2AH	£1.75
Sub D (HP2)	1.25	1.2AH	£1.95
S104 (HP11)	1.25	1.8AH	£2.00
S103 (HP2)	1.25	4.0AH	£3.75
Penlight 4 Charger for 1-4 HP7			£3.25
Combiox FW611 Charger for HP7, HP11, HP2			£13.25
Combiox FW610 Charger for HP7, HP11, HP2			£19.95

CAPACITORS

SIEMENS LAYER 820NF 10mm	SIEMENS LAYER 820NF 10mm	SIEMENS ELECTROLYTIC 20mm
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00
00002 10 220V 1000 10.00	00100 10 220V 1000 10.00	01000 10 220V 1000 10.00

MANY OTHER RANGE CAPACITORS INCLUDE MULLARD C280
MULLARD/SIEMENS CERAMIC SIEMENS 841070 RADIAL
HIGH VOLTAGE DISC CERAMIC, ETC.

LINEAR INTEGRATED CIRCUITS

LF 1331N	2.70	SAA 5000	3.04	"	"	PD335	£34.50	£0.60
LF 13341H	2.70	SAA 5010	7.11	"	"	DM235	£52.50	£1.30
* LM 301.8	0.26	SAA 5012	7.11	"	"	DM390	£72.50	£1.30
* LM 308N	0.48	SAA 5030	5.33	"	"	DM450	£119.00	£1.30
LM 348	0.90	SAA 5030	8.26					
* LM 390N/14	0.50	SAA 5040	15.15					
LM 382	1.56	SAA 5050	8.51					
* LM 386N	0.75	SAS 540	1.60					
* LM 389N	0.92	SAS 570	1.80					
LM 340T5	0.50	SAS 580	1.80					
LM 71014	0.42	SAS 580A	1.80					
LM 723 CH	0.60	SFF 96801A	6.25					
LM 723 CH	0.40	SFF 96801A	4.26					
LM 741 C14	0.58	SFF 96821A	5.19					
LM 923	0.44	* SN 76115	0.70					
LM 1303	1.00	* SN 76228	1.00					
LM 1458	0.40	* SN 76116	1.25					
LM 1801	2.04	* SN 76666	0.70					
LM 1871	1.95	* TAA 263	1.00					
LM 1872	1.95	* TAA 521	0.75					
* LM 3900	0.50	* TAA 621	2.49					
LM 3900	0.50	* TAA 700	1.50					
* LM 3914	2.20	* TAD 100	1.55					
* LM 3915	2.20	* TBA 120	0.75					
LM 4250	1.42	* TBA 500	0.45					
NE 531	0.95	* TBA 550	0.30					
NE 533	1.55	* TBA 830	0.20					
NE 544	1.80	* TBA 8105	1.00					
* NE 555	0.21	* TBA 920	2.75					
* NE 556	0.73	* TBA 9900	2.65					
NE 558	3.12	* TCA 2705	3.15					
NE 562	3.12	* TDA 2540	3.85					
NE 565	1.05	* TDA 2611	1.58					
NE 566	1.53	* TLO 81CP	0.32					
NE 567	1.10	* TLO 82CP	0.56					
NE 570	3.50	* TLO 84CN	1.50					

SINCLAIR INSTRUMENTS

Digital Multimeter	p/p		
DM335	£34.50	£0.60	
DM235	£52.50	£1.30	
DM390	£72.50	£1.30	
DM450	£119.00	£1.30	
Digital Frequency Meter	£49.80	£0.60	
FFM200			
Low Power Oscilloscope	SC110	£139.00	£1.30
TF200 Frequency Meter	£145.00	£1.30	
TGF 105 Pulse Generator	£85.00	£1.30	
NEW			
LCD Multimeter	TM363	£84.00	£1.30
LCD Multimeter	TM351	£99.00	£2.50
LCD Multimeter	TM352	£49.95	£1.30
Prescaler	TP600	£37.50	£0.60
LEADER INSTRUMENTS			
Just a selection			
Singletrace Oscilloscope 510A 5"	£127.00	£3.00	
Doubletrace Oscilloscope 306S 3"	£229.00	£2.50	
Coupler Oscilloscope 508A 5"	£299.00	£2.00	
US 16 Sig. Gen. TV/Radio	£55.00	£2.00	
LDM 815 Dip Meter	£45.00	£1.00	

CRIMSON ELEKTRIK HI FI MODULES

CE 608	Power Amp	£20.09	
CE 1004	Power Amp	£23.43	
CE 1008	Power Amp	£26.30	
CE 1704	Power Amp	£33.48	
CE 1708	Power Amp	£33.48	
CP5 1	Power Unit	£19.52	
CP5 3	Power Unit	£23.52	
CP5 6	Power Unit	£30.00	
CPR 1	Pre Amp	£32.17	
CPR 1	Pre Amp	£42.52	

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2N 697	.10	AD 161	.25	BC 184L	.05	BF 195	.10
2N 914	.10	AF 106	.10	BC 212A	.05	BF 196	.10
2N 929	.10	AF 109	.10	BC 213B	.05	BF 199	.05
2N 3133	.10	AF 126	.10	BC 213L	.05	BSY 28	.10
2N 3568	.50	BC 115	.05	BC 214	.05	MJE 371	.30
2N 3638	.05	BC 118	.05	BC 214B	.05	MPSA 05	.05
2N 3642	.10	BC 154	.10	BC 214L	.05	2T 5000	.05
2N 3705	.10	BC 157A	.05	BC 238B	.05	AA 119	.05
2N 3711	.05	BC 157B	.05	BC 239C	.05	BA 102	.05
2N 3794	.05	BC 158	.05	BC 251B	.05	BA 142	.05
2N 3771	.75	BC 169	.05	BC 253	.08	BA 144	.05
2N 3905	.08	BC 167B	.05	BC 308B	.08	BA 154	.05
2N 3962	.10	BC 168B	.05	BC 360	.05	BA 316	.05
2N 4286	.05	BC 169B	.05	BC 347	.05	BA 317	.05
2N 4400	.05	BC 170B	.05	BC 414	.05	BA 318	.05
2N 5220	.05	BC 171B	.05	BC 415A	.05	BAW 49	.05
2N 5222	.10	BC 172	.05	BC 415A	.05	BAK 13	.05
AC 126	.15	BC 172C	.05	BC 517	.12	BAV 93	.02
AC 127	.15	BC 173	.05	BCV 71	.05	BB 105B	.10
AC 132	.05	BC 174B	.05	BCV 72	.09	BY 126	.14
AC 152	.15	BC 178B	.14	BD 138	.10	CV 7641	.05
AC 188	.15	BC 182A	.05	BF 161	.08	GEX 22A	.03
AC 189	.15	BC 183	.05	BF 177	.05	ITT 44	.05
AC 187K	.15	BC 183B	.06	BF 180	.08	ITT 921	.05
ACY 22	.05	BC 183L	.05	BF 181	.05	OA 47	.10
ACY 30	.05	BC 183 LA	.05	BF 194	.05	OA 90	.05

ILP HI FI MODULES

Power Amplifiers	£7.29		
HY30	£7.29		
HY60	£7.29		
HY120	£17.48		
HY200	£21.21		
HY400	£31.83		
MOS120	£25.88		
MOS200	£33.46		
Power Amplifiers	£7.29		
HY30	£7.29		
HY60	£7.29		
HY120	£17.48		
HY200	£21.21		
HY400	£31.83		
MOS120	£25.88		
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Flashing Diodes (3Hz)	£0.80	BWP 34	£1.18
Rect Leads 2.5 x 5.0mm Red	£0.12	SPH 205	£0.80
Rect Leads 2.5 x 5.0mm Green/Yellow	£0.18	ORP 12	£1.20
		4N25	£0.90

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5" 12 or 24hr mode, 24 alarm with on/off control,
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* CD4002	£0.20	* CD4015	£0.72	* CD40298	£0.60	* CD40518	£0.70	* CD4072	£0.20	* CD4099B	£1.40
* CD4007	£0.20	* CD4016	£0.36	* CD40348	£2.20	* CD40528	£0.70	* CD40738	£0.16	* CD4507	£0.48
* CD4008B	£0.74	* CD4017B	£0.70	* CD40358	£1.10	* CD40608	£1.10	* CD40758	£0.16	* CD45108	£0.90
* CD4009	£0.40	* CD4018B	£0.75	* CD4040	£0.90	* CD4065	£1.10	* CD40818	£0.16	* CD4511	£1.02
* CD4010	£0.40	* CD40198	£0.44	* CD40418	£0.80	* CD40668	£0.45	* CD4082	£0.20	* CD4514	£2.20
* CD4011B	£0.20	* CD40208	£0.60	* CD40428	£0.64	* CD4067	£4.20	* CD4085	£0.90	* CD45208	£0.90
* CD4012	£0.20	* CD40228	£0.78	* CD40478	£1.02	* CD4068	£0.30	* CD4086	£0.90	* CD4522	£1.10

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* SN7404	£0.15	SN7432	£0.21	SN7448	£0.30	SN7474	£0.25	SN74173	£0.24	SN74182	£0.80
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MINI METAL DETECTOR FOR LOCATING PIPES/CABLES UNDER PLASTIC - A MUST FOR EVERY HANDYMAN £9.95

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Carbon with DP switch	ea. 35p
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1M log/amp, 2M2 log	ea. 35p
Dual gain 47K, 1K	ea. 45p
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5K, 15K, 50K	ea. 60p
Thermistor 500 ohm disc	ea. 50p
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1K3, 9K1 only	
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5K1, 5K1, 50K, 1K1, 1K5, 5K6,	ea. 7p
16K, 22K, 5K6, 400K, 910K, 3M9	ea. 7p
Resistors 1W wirewound	
0K27, 0K39, 0K82, 1K5, 1R8, 2R2	ea. 7p
Resistors 3W & 7W wirewound	
1R, 10K (nearly all E12 values)	ea. 7p
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BF597 NPN RF	ea. 20p
BP103 Photo diode	ea. 20p
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F1079, 15V/5V 120mA	ea. 20p
F120K, 30V/5V 250mA	ea. 20p
Diodes	ea. 20p
MS401 PNP silicon TOS	ea. 20p
N4510 14W100 100V 1A 400V	ea. 20p
3A, 4.7, 7.5, 15V	ea. 20p
Capacitors	ea. 20p
3mm, 8, 16, 20mm	ea. 20p
4.7, 10, 16, 20	ea. 20p
10mm, 8, 16, 20, 24mm	ea. 20p
25mm, vert, cap. clips	ea. 20p
Centre zero edge meters 100A	ea. 20p
240V 24W Solenoid relays	ea. 20p
Spares elements	ea. 20p
Sealed lamps 12mm 6V red, amber or clear	ea. 20p
28V red, amber or clear	ea. 20p
CELLS MN1500 220p	ea. 20p
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16-pin IC holders DRD8	ea. 20p
Area Blank Kit	ea. 20p
Veroboard 15" x 3.75" sq.	ea. 20p
200x way main, group boards	ea. 20p
ERT cable, polythene 13/0.2	ea. 20p
on 250 yd drums	ea. 20p
uDisco A, 3.0A, uDisco B	ea. 20p
DeC 8 or 10-way IC carriers	ea. 20p
DeC 1mm plugs gold flash	ea. 20p
Standard jacks, incl. MONO chrome	ea. 20p
without switch contacts 50/55	ea. 20p
Edge connectors 36-way, 1" / 5/8	ea. 20p
16 or 24 way 1/5" S/S gold flt	ea. 20p
36 way, 1/5" S/S gold flt	ea. 20p
1mm under way for sockets	ea. 20p
Radio make switches	ea. 20p
2PW4, 4V15V, 6P2W, 1P11W	ea. 20p
make main switch	ea. 20p
Silvered mica, incl. 1W or 5pF	ea. 20p
PC1 8mm 200V, 47pF	ea. 20p
PC1 12mm 1500V, 300pF	ea. 20p
PC1 16mm 3000V, 470pF, 500pF, 820pF	ea. 20p
PC1 20mm 1500V, 300pF	ea. 20p
Polycarbonate PC10 10mm 100V	ea. 20p
G015, 0.047uF	ea. 20p
Electrolytic caps 22uF 250V	ea. 20p
Pluggable 220uF 3V	ea. 20p
axial Mullard 220 10, 220/40	ea. 20p
4, 7/50, 10/63, 22/63, 100/10	ea. 20p
axial Siemens 47/5, 100/3	ea. 20p
2200/6.3V	ea. 20p

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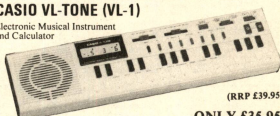


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LINEAR CIRCUITS		LM339N 35p		4039 55p		7468 75p		74222 160p		BD180 34p		TX5025 15p					
709-8		LM339N 35p		4040 55p		7469 75p		74223 160p		BD180 34p		TX5026 15p					
710-14		LM339N 35p		4041 55p		7470 75p		74224 160p		BD180 34p		TX5027 15p					
711-8		LM339N 35p		4042 55p		7471 75p		74225 160p		BD180 34p		TX5028 15p					
712-14		LM339N 35p		4043 55p		7472 75p		74226 160p		BD180 34p		TX5029 15p					
713-14		LM339N 35p		4044 55p		7473 75p		74227 160p		BD180 34p		TX5030 15p					
714-14		LM339N 35p		4045 55p		7474 75p		74228 160p		BD180 34p		TX5031 15p					
715-14		LM339N 35p		4046 55p		7475 75p		74229 160p		BD180 34p		TX5032 15p					
716-14		LM339N 35p		4047 55p		7476 75p		74230 160p		BD180 34p		TX5033 15p					
717-14		LM339N 35p		4048 55p		7477 75p		74231 160p		BD180 34p		TX5034 15p					
718-14		LM339N 35p		4049 55p		7478 75p		74232 160p		BD180 34p		TX5035 15p					
719-14		LM339N 35p		4050 55p		7479 75p		74233 160p		BD180 34p		TX5036 15p					
720-14		LM339N 35p		4051 55p		7480 75p		74234 160p		BD180 34p		TX5037 15p					
721-14		LM339N 35p		4052 55p		7481 75p		74235 160p		BD180 34p		TX5038 15p					
722-14		LM339N 35p		4053 55p		7482 75p		74236 160p		BD180 34p		TX5039 15p					
723-14		LM339N 35p		4054 55p		7483 75p		74237 160p		BD180 34p		TX5040 15p					
724-14		LM339N 35p		4055 55p		7484 75p		74238 160p		BD180 34p		TX5041 15p					
725-14		LM339N 35p		4056 55p		7485 75p		74239 160p		BD180 34p		TX5042 15p					
726-14		LM339N 35p		4057 55p		7486 75p		74240 160p		BD180 34p		TX5043 15p					
727-14		LM339N 35p		4058 55p		7487 75p		74241 160p		BD180 34p		TX5044 15p					
728-14		LM339N 35p		4059 55p		7488 75p		74242 160p		BD180 34p		TX5045 15p					
729-14		LM339N 35p		4060 55p		7489 75p		74243 160p		BD180 34p		TX5046 15p					
730-14		LM339N 35p		4061 55p		7490 75p		74244 160p		BD180 34p		TX5047 15p					
731-14		LM339N 35p		4062 55p		7491 75p		74245 160p		BD180 34p		TX5048 15p					
732-14		LM339N 35p		4063 55p		7492 75p		74246 160p		BD180 34p		TX5049 15p					
733-14		LM339N 35p		4064 55p		7493 75p		74247 160p		BD180 34p		TX5050 15p					
734-14		LM339N 35p		4065 55p		7494 75p		74248 160p		BD180 34p		TX5051 15p					
735-14		LM339N 35p		4066 55p		7495 75p		74249 160p		BD180 34p		TX5052 15p					
736-14		LM339N 35p		4067 55p		7496 75p		74250 160p		BD180 34p		TX5053 15p					
737-14		LM339N 35p		4068 55p		7497 75p		74251 160p		BD180 34p		TX5054 15p					
738-14		LM339N 35p		4069 55p		7498 75p		74252 160p		BD180 34p		TX5055 15p					
739-14		LM339N 35p		4070 55p		7499 75p		74253 160p		BD180 34p		TX5056 15p					
740-14		LM339N 35p		4071 55p		7500 75p		74254 160p		BD180 34p		TX5057 15p					
741-14		LM339N 35p		4072 55p		7501 75p		74255 160p		BD180 34p		TX5058 15p					
742-14		LM339N 35p		4073 55p		7502 75p		74256 160p		BD180 34p		TX5059 15p					
743-14		LM339N 35p		4074 55p		7503 75p		74257 160p		BD180 34p		TX5060 15p					
744-14		LM339N 35p		4075 55p		7504 75p		74258 160p		BD180 34p		TX5061 15p					
745-14		LM339N 35p		4076 55p		7505 75p		74259 160p		BD180 34p		TX5062 15p					
746-14		LM339N 35p		4077 55p		7506 75p		74260 160p		BD180 34p		TX5063 15p					
747-14		LM339N 35p		4078 55p		7507 75p		74261 160p		BD180 34p		TX5064 15p					
748-14		LM339N 35p		4079 55p		7508 75p		74262 160p		BD180 34p		TX5065 15p					
749-14		LM339N 35p		4080 55p		7509 75p		74263 160p		BD180 34p		TX5066 15p					
750-14		LM339N 35p		4081 55p		7510 75p		74264 160p		BD180 34p		TX5067 15p					
751-14		LM339N 35p		4082 55p		7511 75p		74265 160p		BD180 34p		TX5068 15p					
752-14		LM339N 35p		4083 55p		7512 75p		74266 160p		BD180 34p		TX5069 15p					
753-14		LM339N 35p		4084 55p		7513 75p		74267 160p		BD180 34p		TX5070 15p					
754-14		LM339N 35p		4085 55p		7514 75p		74268 160p		BD180 34p		TX5071 15p					
755-14		LM339N 35p		4086 55p		7515 75p		74269 160p		BD180 34p		TX5072 15p					
756-14		LM339N 35p		4087 55p		7516 75p		74270 160p		BD180 34p		TX5073 15p					
757-14		LM339N 35p		4088 55p		7517 75p		74271 160p		BD180 34p		TX5074 15p					
758-14		LM339N 35p		4089 55p		7518 75p		74272 160p		BD180 34p		TX5075 15p					
759-14		LM339N 35p		4090 55p		7519 75p		74273 160p		BD180 34p		TX5076 15p					
760-14		LM339N 35p		4091 55p		7520 75p		74274 160p		BD180 34p		TX5077 15p					
761-14		LM339N 35p		4092 55p		7521 75p		74275 160p		BD180 34p		TX5078 15p					
762-14		LM339N 35p		4093 55p		7522 75p		74276 160p		BD180 34p		TX5079 15p					
763-14		LM339N 35p		4094 55p		7523 75p		74277 160p		BD180 34p		TX5080 15p					
764-14		LM339N 35p		4095 55p		7524 75p		74278 160p		BD180 34p		TX5081 15p					
765-14		LM339N 35p		4096 55p		7525 75p		74279 160p		BD180 34p		TX5082 15p					
766-14		LM339N 35p		4097 55p		7526 75p		74280 160p		BD180 34p		TX5083 15p					
767-14		LM339N 35p		4098 55p		7527 75p		74281 160p		BD180 34p		TX5084 15p					
768-14		LM339N 35p		4099 55p		7528 75p		74282 160p		BD180 34p		TX5085 15p					
769-14		LM339N 35p		4100 55p		7529 75p		74283 160p		BD180 34p		TX5086 15p					
770-14		LM339N 35p		4101 55p		7530 75p		74284 160p		BD180 34p		TX5087 15p					
771-14		LM339N 35p		4102 55p		7531 75p		74285 160p		BD180 34p		TX5088 15p					
772-14		LM339N 35p		4103 55p		7532 75p		74286 160p		BD180 34p		TX5089 15p					
773-14		LM339N 35p		4104 55p		7533 75p		74287 160p		BD180 34p		TX5090 15p					
774-14		LM339															

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TYPE	SERIES No.	SECONDARY RMS Volts	CURRENT	PRICE
30va 70x30mm 0.45 Kg	1X011	6+6	2.12	£4.48 +£0.87p P/P +£0.80p VAT
	1X012	9+9	1.96	
	1X013	12+12	1.25	
	1X014	15+15	1.00	
	1X015	18+18	0.83	
	1X016	22+22	0.68	
	1X017	25+25	0.60	
50va 80x35mm 0.9 Kg	2X010	6+6	4.16	£4.93 +£1.10p P/P +£0.90p VAT
	2X011	9+9	2.77	
	2X012	12+12	2.06	
	2X013	15+15	1.66	
	2X014	18+18	1.38	
	2X015	22+22	1.13	
	2X016	25+25	1.00	
80va 90x30mm 1 Kg	3X010	6+6	6.64	£5.47 +£1.43 P/P +£1.04 VAT
	3X011	9+9	4.44	
	3X012	12+12	3.33	
	3X013	15+15	2.66	
	3X014	18+18	2.22	
	3X015	22+22	1.81	
	3X016	25+25	1.60	
120va 80x40mm 1.2 Kg	4X010	6+6	10.00	£6.38 +£1.43 P/P +£1.17 VAT
	4X011	9+9	6.66	
	4X012	12+12	5.00	
	4X013	15+15	4.00	
	4X014	18+18	3.33	
	4X015	22+22	2.72	
	4X016	25+25	2.40	
160va 110x40mm 1.8 Kg	5X010	6+6	13.33	£8.44 +£1.43 P/P +£1.48 VAT
	5X011	9+9	8.89	
	5X012	12+12	6.66	
	5X013	15+15	5.33	
	5X014	18+18	4.44	
	5X015	22+22	3.63	
	5X016	25+25	3.20	
225va 110x50mm 2.2 Kg	6X010	6+6	16.66	£10.06 +£1.77 P/P +£1.77 VAT
	6X011	9+9	11.11	
	6X012	12+12	8.33	
	6X013	15+15	6.66	
	6X014	18+18	5.55	
	6X015	22+22	4.54	
	6X016	25+25	4.00	
300va 110x50mm 2.8 Kg	7X010	6+6	20.00	£11.66 +£1.73 P/P +£2.01 VAT
	7X011	9+9	13.33	
	7X012	12+12	10.00	
	7X013	15+15	8.00	
	7X014	18+18	6.66	
	7X015	22+22	5.55	
	7X016	25+25	5.00	
500va 140x60mm 4 Kg	8X010	6+6	25.00	£15.53 +£2.05 P/P +£2.64
	8X011	9+9	16.66	
	8X012	12+12	12.50	
	8X013	15+15	10.00	
	8X014	18+18	8.33	
	8X015	22+22	6.80	
	8X016	25+25	6.00	

TYPE	SERIES No.	SECONDARY RMS Volts	CURRENT	PRICE
160va 110x40mm 1.8 Kg	5X012	12+12	6.66	£8.44 +£1.43 P/P +£1.48 VAT
	5X013	15+15	5.33	
	5X014	18+18	4.44	
	5X015	22+22	3.63	
	5X016	25+25	3.20	
	5X017	30+30	2.66	
	5X018	35+35	2.28	
225va 110x50mm 2.2 Kg	6X014	18+18	6.25	£10.06 +£1.77 P/P +£1.77 VAT
	6X015	22+22	5.11	
	6X016	25+25	4.50	
	6X017	30+30	3.75	
	6X018	35+35	3.21	
	6X026	40+40	2.81	
	6X028	110	2.04	
300va 110x50mm 2.8 Kg	7X029	220	1.72	£11.66 +£1.73 P/P +£2.01 VAT
	7X030	240	0.95	
	7X016	25+25	6.00	
	7X017	30+30	5.00	
	7X018	35+35	4.28	
	7X026	40+40	3.75	
	7X025	45+45	3.33	
500va 140x60mm 4 Kg	8X029	220	1.02	£15.53 +£2.05 P/P +£2.64
	8X030	240	0.95	
	8X017	30+30	8.33	
	8X018	35+35	7.14	
	8X026	40+40	6.25	
	8X025	45+45	5.55	
	8X033	50+50	5.00	

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1401 10p. 1402 10p. 1403 10p. 1404 10p. 1405 10p. 1406 10p. 1407 10p. 1408 10p. 1409 10p. 1410 10p. 1411 10p. 1412 10p. 1413 10p. 1414 10p. 1415 10p. 1416 10p. 1417 10p. 1418 10p. 1419 10p. 1420 10p. 1421 10p. 1422 10p. 1423 10p. 1424 10p. 1425 10p. 1426 10p. 1427 10p. 1428 10p. 1429 10p. 1430 10p. 1431 10p. 1432 10p. 1433 10p. 1434 10p. 1435 10p. 1436 10p. 1437 10p. 1438 10p. 1439 10p. 1440 10p. 1441 10p. 1442 10p. 1443 10p. 1444 10p. 1445 10p. 1446 10p. 1447 10p. 1448 10p. 1449 10p. 1450 10p. 1451 10p. 1452 10p. 1453 10p. 1454 10p. 1455 10p. 1456 10p. 1457 10p. 1458 10p. 1459 10p. 1460 10p. 1461 10p. 1462 10p. 1463 10p. 1464 10p. 1465 10p. 1466 10p. 1467 10p. 1468 10p. 1469 10p. 1470 10p. 1471 10p. 1472 10p. 1473 10p. 1474 10p. 1475 10p. 1476 10p. 1477 10p. 1478 10p. 1479 10p. 1480 10p. 1481 10p. 1482 10p. 1483 10p. 1484 10p. 1485 10p. 1486 10p. 1487 10p. 1488 10p. 1489 10p. 1490 10p. 1491 10p. 1492 10p. 1493 10p. 1494 10p. 1495 10p. 1496 10p. 1497 10p. 1498 10p. 1499 10p. 1500 10p. 1501 10p. 1502 10p. 1503 10p. 1504 10p. 1505 10p. 1506 10p. 1507 10p. 1508 10p. 1509 10p. 1510 10p. 1511 10p. 1512 10p. 1513 10p. 1514 10p. 1515 10p. 1516 10p. 1517 10p. 1518 10p. 1519 10p. 1520 10p. 1521 10p. 1522 10p. 1523 10p. 1524 10p. 1525 10p. 1526 10p. 1527 10p. 1528 10p. 1529 10p. 1530 10p. 1531 10p. 1532 10p. 1533 10p. 1534 10p. 1535 10p. 1536 10p. 1537 10p. 1538 10p. 1539 10p. 1540 10p. 1541 10p. 1542 10p. 1543 10p. 1544 10p. 1545 10p. 1546 10p. 1547 10p. 1548 10p. 1549 10p. 1550 10p. 1551 10p. 1552 10p. 1553 10p. 1554 10p. 1555 10p. 1556 10p. 1557 10p. 1558 10p. 1559 10p. 1560 10p. 1561 10p. 1562 10p. 1563 10p. 1564 10p. 1565 10p. 1566 10p. 1567 10p. 1568 10p. 1569 10p. 1570 10p. 1571 10p. 1572 10p. 1573 10p. 1574 10p. 1575 10p. 1576 10p. 1577

Index to Advertisers

Acorn	5
Adam Hall (P.E. Supplies)	92
Aiken Bros	83
Alcon Instruments	14
Alfa Design & Engineering Services	90
Barrie Electronics	86
Bib Hi-Fi Accessories	43
B.I.E.T.	25
BI-Pak	22
Bolster Instruments	91
British National Radio & Electronics School	93
Butterworths	44
Cambridge Kits	91
CDI Electronics Systems	10, 11
Chromasonic Electronics	83
Clef Products	92
Colour Print Express	Cover II
Computer Components (Teleyay)	Cover III
Crofton Electronics	92
C.R. Supply	90
C.U.A.	82
Davies	89
Delta-Tech	93
Doran	4
Electrovalue	88
Enviro Systems	89
Feltglow	86
Flairline Supplies	92
GJD Electronics	91
Gemini	8
Global Specialties Corporation	11, 63
Hamley Ltd	75
Haydn Manning Ltd	91
Henry's Radio	84
Hylkon Ltd	91
Home Radio	94
I.C.S. Intertex	90, 75
I.L.P. Electronics	80, 81, 94
L & B Electronics	14
London College of Furniture	86
Maplin Electronic	Cover IV
Marshall, A	87
Micro Circuits	15
Micro Times	30
Midwich Computers	7
Micro Peripherals (Mighty Micro)	37
Millihill	86
Modern Book Co.	88
Muscraft	84
Mutek	63
Nautical College	91
N.I.C.	91
Northern Micro	90
Pantec	8
Parndon	95
Phonosonics	6, 7
PKG Electronics	92
Prentice-Hall	95
Progressive Radio	94
Proto Design	92
Radio Component Specialists	88
Radio & T.V. Components	16
Rapid Electronics	82
Safgan	8
Sandwell Plant	91
Saxon Entertainments	49
Science of Cambridge	12, 13
Scientific Wire Co.	92
Service Trading	85
Swanley Electronics	92
Tangerine	29
Tempus	89
Technomatic	96
Titan	84
T.K. Electronics	9
TUAC	82
Videotone	67
Watford Electronics	2, 3
William Stuart Systems	92
Wilmislow Audio	89

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